GRANTS RECLAMATION PROJECT GROUNDWATER CORRECTIVE ACTION PROGRAM (CAP) REVISION

Prepared For:

HOMESTAKE MINING COMPANY OF CALIFORNIA

P.O. Box 98 - State Highway 605
Grants, NM 87020

Prepared By:

consulting
scientists and
engineers

3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

December 12, 2006

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1.0 INTRODUCTION

This report describes the current groundwater corrective action program at the Homestake Mining Company of California (Homestake) Grants Reclamation Project. The report, or Revised CAP, also describes the enhancements to the existing program that is specified in NRC License SUA-1471, License Condition 35 C. The revised program presented here reflects an expansion of the current program at the site, and is intended to describe planned activities that are to be covered under this license condition.

The Revised CAP integrates modifications to the ongoing groundwater corrective actions that have occurred at the site since groundwater remediation started in 1977. The Revised CAP was developed based on the observed response of the impacted aquifers and does not rely exclusively on the results of modeling. This allows for a higher degree of confidence that the CAP will achieve the objectives for groundwater concentrations set for the CAP. Therefore, the format of the Revised CAP is significantly different than a typical submittal, such as the guidelines envisioned in the Standard Review Plan (NUREG 1620).

The body of the following report is structured in a manner that logically describes the historic and geologic setting (Section 2), a description of the Revised CAP (Section 3), the proposed monitoring program (Section 4), a financial surety cost estimate (Section 5) and conclusions (Section 6). A summary table outlining the acceptance criteria from NUREG 1620 is included as Table 1-1 and provides the location of each of the key components of the plan relative to the required check list from the guidance document. Hydraulic and transport modeling are used for this application, and the results are presented in Appendix C.

Table 1-1 Groundwater Corrective Action and Compliance Monitoring Plan

NUREG-1620 Checklist Item		Revised CAP Section
1.	Sufficient data are available to adequately define relevant parameters and to support models, assumptions, and boundary conditions necessary for developing detailed and site-scale models of the groundwater cleanup and the estimation of cleanup time. The data are also sufficient to assess the degree to which processes related to the groundwater cleanup that affect compliance with the technical criteria in Appendix A of 10 CFR Part 40 have been characterized. Information required for site-scale reactive transport models can include:	2.4
a.	Site description:	
	(i) Chronology/history of uranium milling operations	2.2
	(ii) List of known leaching solutions and other chemicals used in the milling process	2.2
	(iii) Summary of known impacts of the site activities on the hydrologic system and backgroundwater quality. Protecting Water Resources	2.3, 2.5, 2.7
	(iv) Quantity and chemical/textural characteristics of wastes generated at the mill site	2.2
	(v) Information pertaining to surrounding land and water uses	2.8
	(vi) Meteorological data for the region including precipitation and other data to support estimates of evapotranspiration	2.1
b.	Description of hydrogeologic units: (i) Hydrostratigraphic cross sections/maps (ii) Hydrogeologic units that constitute the aquifer(s) (iii) Description of perched aquifers (areal/volumetric extent) (iv) Description of the unsaturated zone (thickness, extent) (v) Geologic characteristics (presence of layers, continuity, faults)	2.4
c.	Data on the hydraulic and transport properties of each aquifer:	
	(i) Hydraulic conductivity (ii) Thickness of each unit (iii) Hydraulic head contour maps (of each aquifer) (iv) Information on background horizontal and vertical hydraulic gradients and temporal variations to determine flow directions (v) Vertical hydraulic gradients and inter-aquifer flow within and between multiple aquifer systems (vi) Effective porosity (vii) Storativity or specific yield (for transient simulations) (viii) Longitudinal, vertical and horizontal transverse dispersivity (ix) Retardation factors	2.4 3.2, Appendix C

Table 1-1 Groundwater Corrective Action and Compliance Monitoring Plan (continued)

NUREG-1620 Checklist Item		Revised CAP Section
c.	Data on regional recharge rates and groundwater/surface water interactions with nearby streams, rivers, or lakes: (i) Areal recharge rates. (ii) Information on water fluxes to and from rivers, aquifers, and surface water bodies (iii) Data on surface water bodies (e.g., stream flow rates, dimensions of nearby surface water bodies) (iv) Concentration of hazardous constituents in surface water bodies	Groundwater: Hydro-Engineering (2000) Surface water: N/A
d.	Characteristics of the mill tailings:	
	(i) Identification of contaminant source terms	2.2
	(ii) Hydraulic properties of mill tailings material (iii) Unsaturated flow and transport parameters of mill tailings material	Hydro-Engineering (1996)
	(iv) Design and materials for mill tailings cover	1993 Reclamation Plan
	(v) Information on the spatial and temporal distribution of seepage fluxes from the mill tailings to the upper-most aquifer (including the historical variation in rates) (vi) Information on mill tailings draining mechanisms and drainage volume	Appendix C
	(vii) Geotechnical properties of the mill tailings and their temporal variation due to drainage of leachates (viii) Tailings volume (ix) Data on the volume, chemical and mineralogical characteristics, and concentration of mill tailings and tailings solution/leachate	2.2
	(x) Mass of hazardous constituents placed in the tailings pile and other disposal or storage areas	2.2
e.	Data on geochemical conditions and water quality:	
	(i) Concentration of hazardous constituents	2.6
	(ii) Background (baseline) groundwater quality	2.5
	(iii) Delineation of the nature and extent of the hazardous constituent plume	2.7, 3.16
	(iv) Characterization of subsurface geochemical properties	Hydro-Engineering (2000)
	(v) Identification of attenuation mechanisms and estimation of attenuation rates	Appendix C
	(vi) Mass of hazardous constituents in the aquifer	Hydro-Engineering (2000)
f.	Site cleanup data: (i) Information on grout curtains, slurry walls, drains, interceptor ditches, and other facilities designed to reduce the spreading of the hazardous constituent plume (if used) (ii) Information on pumping, injection, and sampling wells (coordinates, depths, completion diagrams, flow rates) (iii) Pumping/injection rates and rate history for each well (if pumping has been ongoing) (iv) Information on the presence or the absence of liners for the mill tailings pile and evaporation ponds	2.3, 3.0
	(v) Mass of hazardous constituents recovered to date	Homestake and Hydro-Engineering (2006)

Table 1-1 Groundwater Corrective Action and Compliance Monitoring Plan (continued)

NUREG-1620 Checklist Item		Revised CAP Section
2.	Parameter values, assumed ranges, probability distributions, and/or bounding assumptions used in the modeling of groundwater cleanup are technically defensible and reasonably account for uncertainties and variabilities. The technical bases for each parameter value, ranges of values, or probability distributions used in the modeling of the groundwater cleanup are provided. Sensitivity analyses are provided that (i) identify aquifer flow and transport parameters that are expected to significantly affect the site model outcome; (ii) test the degree to which the performance of the groundwater cleanup may be affected if a range of parameter values must be used as input to the model due to sparsity of, or uncertainty in, available data; and (iii) test for the need for additional data. Sufficient bases are provided for parameter values, representative parameter values are taken from the literature, and the bounds and statistical distributions are provided for hydrologic and transport parameters that are important to the estimation of cleanup time and that are included in the modeling of the groundwater cleanup. Site data fitted to theoretical models compare reasonably well. American Standard for Testing and Materials D 5490 provides guidance for comparing groundwater flow model simulations to site-specific information. If there is departure of site data from the theoretical model, then an alternative model is considered. The assumptions used in modeling are consistent with site data and observations. Models used to describe local phenomena, such as the fluxes through the tailings pile, are based on consistently applied conditions.	Appendix C
3.	Important design features, physical phenomena, and consistent and appropriate assumptions are identified and described sufficiently for incorporation into any modeling that supports the groundwater cleanup, including the estimate of cleanup time, and the technical bases are provided. Detailed models and site-scale models used to support the corrective action plan, or other supporting documents, and identify and describe aspects that are important to the cleanup and the estimate of cleanup time.	Appendix C
4.	Alternative modeling approaches consistent with available data and current scientific understanding are investigated where necessary, and results and limitations are appropriately factored into the groundwater corrective action plan. The licensee provides sufficient evidence that relevant site features have been considered, that the models are consistent with available data and current scientific understanding, and that the effects on cleanup time have been evaluated. Specifically, the licensee adequately considers alternative modeling approaches where necessary to incorporate uncertainties in site parameters and ensure they are propagated through the modeling. Uncertainty in data interpretations is considered by analyzing reasonable conceptual models that are supported by site data, or by demonstrating through sensitivity studies that the uncertainties have little impact on the groundwater corrective action plan.	N/A

Table 1-1 Groundwater Corrective Action and Compliance Monitoring Plan (continued)

NUREG-1620 Checklist Item		Revised CAP Section
5.	The site-scale model for groundwater cleanup provides results consistent with the output of detailed or site data. Specifically, the site model is consistent with detailed models of geological, hydrological, and geochemical processes for the site. For example, for flow and transport through the aquifer, hydraulic conductivity distributions are reasonably consistent with sensitivity studies of the range of hydraulic conductivities and varying statistical distributions, field observations, and laboratory tests, when applicable. The licensee documents how the model output is validated in relation to site characteristics. Where appropriate, in developing the site model for groundwater cleanup, the licensee considers and evaluates alternative models that are reasonably justified by the available database, with reasonable values assigned to distribution statistics to compensate for limited data availability. The licensee uses numerical and analytical modeling approaches reflecting varying degrees of complexity consistent with information obtained from site characterization. The licensee employs the upper and lower bounds of input parameter ranges to examine the robustness of the modeling.	Appendix C
6.	Adequate waste management practices are defined. The disposition of effluent generated during active remediation is addressed in the corrective action plan. Appendix F to this standard review plan contains NRC staff policy for effluent disposal at licensed uranium recovery facilities for conventional mills. When retention systems such as evaporation ponds are used, design considerations from erosion protection and stability along with construction plans reviewed by a qualified engineer are included. Evaporation and retention ponds should meet the design requirements of 10 CFR Part 40, Appendix A, Criterion 5A. Ideally, the ponds should have leak detection systems capable of reliably detecting a leak from the pond into the groundwater and should be located where they will not impede the timely surface reclamation of the tailings impoundment.	3.12, 3.14
	If water is to be treated and reinjected, either into an upper aquifer or into a deep disposal well, the injection program is approved by the appropriate state or federal authority.	3.12
	If effluent is to be discharged to a surface-water body, licensees obtain a National Pollutant Discharge Elimination System permit for discharge to surface water. If plans to manage effluents are in place from earlier operations, they may be included in the corrective action plan by reference.	3.13
7.	Appropriate site access control is provided by the licensee. Site access control should be provided by the licensee until site closure to protect human health and the environment from potential harm. Site access is controlled by limiting access to the site with a fence and by conducting periodic inspections of the site.	2.2, 2.3, 2.8

Table 1-1 Groundwater Corrective Action and Compliance Monitoring Plan (continued)

8.	Effective corrective action and compliance monitoring programs are provided. Licensees are required, by Criterion 7 of Appendix A to 10 CFR Part 40, to implement corrective action and compliance monitoring programs. The licensee monitoring programs are adequate to evaluate the effectiveness of groundwater cleanup and control activities, and to monitor compliance with groundwater cleanup standards. The description of the monitoring program includes or references the following information:	2.7, 4.0
a.	(a) QA procedures used for collecting, handling, and analyzing groundwater samples;	4.3
b.	(b) The number of monitor wells and their locations;	4.1, 4.2
c.	(c) A list of constituents that are sampled and the monitoring frequency for each monitored constituent;	4.1, 4.2
d.	(d) Action levels that trigger implementation of enhanced monitoring or revisions to cleanup activities (i.e., timeliness and effectiveness of the corrective action).	2.6
9.	Design of Surface Impoundments. The reviewer shall determine that any lined impoundment built as part of the corrective-action program to contain wastes is acceptably designed, constructed, and installed. The design, installation, and operation of these surface impoundments must meet relevant guidance provided in Regulatory Guide 3.11, Section 1 (NRC 1977). Materials used to construct the liner shall be reviewed to determine that they have acceptable chemical properties and sufficient strength for the design application. The reviewer shall determine that the liner will not be overtopped. The reviewer shall determine that a proper quality control program is in place. (see source doc for more information on this)	3.13
10.	Financial Surety is Provided. The licensee must maintain a financial surety, within the specific license, for the restoration of groundwater, with the surety sufficient to recover the anticipated cost and time frame for achieving compliance before the land is transferred to the long-term custodian. The financial surety must be sufficient to cover the cost of corrective action measures that will have to be implemented if required to restore groundwater quality to the established site-specific standards (including an ACL standard) before the site is transferred to the government for long-term custody.	5.0

2.0 SITE SETTING AND HISTORY

This section of the report describes the existing site conditions, including the site location and climate, the operational history, a history of the groundwater remediation, the geologic and hydrologic setting, backgroundwater quality, hazardous constituents, existing groundwater monitoring and current conditions, and a summary of the surrounding land and groundwater use.

2.1 Site Location and Climate

The Homestake uranium milling/processing site is located approximately 5.5 miles north of Milan, New Mexico in Section 26, Township 12 North, Range 10 West, in Cibola County (Figure 1).

The Grants site is at an elevation of 6,600 feet above mean sea level (MSL). The climate is typical of high desert, with average precipitation of 10.4 inches and evaporation of 54.6 inches per year. Maximum precipitation typically occurs due to thunderstorms in July, August and September. Average precipitation for the remainder of the year is roughly one-half inch each month. Figure 2 presents the total yearly precipitation for the Grants site from 1996 through 2006. Evaporation is highest in May, June and early July because the onset of the rainy season (usually in mid-July) reduces evaporation in the second half of the summer.

2.2 Operational History

The Homestake mill produced uranium concentrate from 1958 until 1990. Homestake's milling facilities were constructed and originally operated as two distinct partnerships, with Homestake Mining Company acting as the managing partner of both. The larger of the two mills was organized as Homestake-Sapin Partners, with a nominal milling capacity of 1,750 tons per day (tpd). The smaller of the two mills was organized as Homestake-New Mexico Partners with a nominal milling capacity of 1,650 tpd. Both mills were designed to be alkaline leach-caustic precipitation processes for concentrating uranium oxide from ores with average grades of 0.05 to 0.30 percent U_3O_8. Combining these two milling facilities in 1961 resulted in a mill with a nominal through-put capacity of 3,400 tpd. A summary of the details of the mill operation including the process chemistry for the mill is summarized in "A Report on Alkaline Carbonate Leaching at Homestake Mining Company" (Skiff and Turner, 1981), which is provided as Appendix A .

The Homestake-New Mexico Partners Mill commenced operations in April 1958, while the Homestake-Sapin Partners Mill started up in May 1958. The mills operated independently, each with its own tailings impoundments, until November 9, 1961, when the partnerships were merged. Homestake-Sapin Partners was the surviving organization.

In January 1962, the former New Mexico Partners Mill ceased operations as a complete and independent mill. The Sapin Partners Mill continued to use a portion of the smaller mill's facilities. In April 1968, United Nuclear Corporation acquired an interest in the partnership, and the operation became known as United Nuclear-Homestake Partners. United Nuclear's interest was purchased by Homestake in March 1981 and the operation became Homestake Mining Company-Grants.

Two tailings impoundments were developed on the Grants site. The first and smaller of the two impoundments contains tailings from ore milled under contracts with the federal government. The total quantity of tailings placed in this first impoundment was 1.22 million tons. It is located in the SE ¼ and SW ¼ of Section 26, Township 12 North, Range 10 West, NMPM. Tailings deposited within this impoundment were contained entirely by an embankment composed of compacted natural soils. The embankment was compacted by heavy equipment and raised to a height of 20-25 feet. The crest was a minimum of 10 feet wide, with the base being approximately 40 feet wide. The impoundment covers an area of about 40 acres. In 1990, an evaporation pond was constructed in this impoundment to assist in the dewatering of the large tailing impoundment and to hold water pumped from the collection wells associated with the groundwater remediation program. More recently, this evaporation pond, along with other lined ponds that were constructed nearby, have been used to evaporate the brine from the reverse osmosis (RO) water treatment plant.

The larger of the two tailings impoundments, located in the N ½, Section 26, Township 12 North, Range 10 West, NMPM, contains tailings from ore milled under both federal government and commercial contracts. The total quantity of tailings generated under AEC contracts was 11.41 million tons. In addition, another 10.89 million tons of commercial tailings were generated and commingled with the AEC tailings. Until 1966, HMC deposited tailings into only one cell of the large impoundment. Subsequently, HMC added an additional cell adjacent to and west of the existing cell. From 1966 until 1990, tailings disposal alternated between the two cells (east and west) as necessary to maintain optimal operating conditions. The starter dike for the large impoundment was constructed in compacted six-inch lifts of natural soils excavated from within the tailings impoundment area. The dike was constructed to a height of approximately 10 feet and a width of approximately 10-15 feet at the top and 25-30 feet at the bottom. The impoundment's perimeter embankment was raised by the centerline method until 1981, when an inboard offset of the embankment was made to improve impoundment stability conditions. Subsequent lifts were added to the offset perimeter embankment by the centerline method. The impoundment presently covers approximately 170 acres and is approximately 85-100 feet high. The east and west ponds cover approximately 55 and 40 acres, respectively, as measured from the embankment crest centerline.

Throughout most of its operation, the large impoundment was constructed by splitting the slurried mill tailings into coarse and fine fraction using a cyclone separator. The coarse fraction was hydraulically placed along the centerline and outslope to build the impoundment by the centerline method. The fine portion of tailings was discharged across the beach toward the pond. Mill tailings are composed of uranium-depleted fine and coarse sand fractions and slimes consisting of minus No. 200 mesh-sized materials. The clarified liquid that was discharged into the pond was recycled through decant towers back to the mill for reuse as process water. During the latter stages of mill operations, when production rates were low, cyclone separation was not used and the tailings slurry was discharged directly across the beaches into the tailings pond. This method of operation confined disposal to a single pond at a time, with the other pond used for evaporation as needed. The large tailings impoundment received 21.05 million tons of tailings. HMC discontinued milling operations in February 1990.

Interim reclamation of the large tailings impoundment was completed in 1995. This work consisted of regrading the side slopes to 5:1 (horizontal:vertical) and covering these slopes with three feet of compacted radon barrier material (sandy clay) and 8 inches of rock. The top surface of the impoundment was covered with a minimum of 0.5 feet of interim cover. Final reclamation of the large tailings impoundment will be completed once the wells in the tailings impoundment are no longer needed, and a final determination is made concerning acceptable tailings consolidation and settlement.

2.3 Groundwater Remediation History

At the time the Grants Mill was built, it was located in a remote ranch land area. In the 1960's and 1970s, several subdivisions were developed in the vicinity of the Grants Mill. Many of the original owners of these residences used domestic wells completed in alluvium and shallow bedrock aquifers in which the natural water quality was generally poor.

Starting in the late 1950s, the Atomic Energy Commission (AEC) required monitoring for groundwater protection. Sampling was done on a quarterly basis and reviewed by AEC. The AEC regulations specified detailed limits on releases to both air and water. Monitoring did not show any increase in radioactive materials through the mid-1970s. At this time, a State and EPA study of the New Mexico uranium industry detected elevated selenium levels in domestic water of one of the neighboring subdivisions. At that time, Homestake and others undertook a more comprehensive groundwater sampling program. The source of the selenium was uncertain. Possible sources included: (a) groundwater from Poison Canyon, an area named from the locoweed which grows selectively on selenium rich soil, causing the background selenium levels to be very high; (b) seepage from the tailings impoundment as a result of the carbonate leach process, which causes a portion of the natural selenium

contained in the ore to be soluble; and (c) discharges from other mines and mills in the area. The State, Homestake and several of the residents met to discuss the situation. Homestake agreed, without regard to the sources of the selenium, to address selenium levels in the wells.

Homestake supplied bottled drinking water to any of the subdivision residents requesting it. Homestake also undertook an extensive hydrologic study of the area. As a result of this study, Homestake implemented one of the first groundwater restoration and protection programs related to effects from uranium mill tailings. A series of fresh water injection wells were installed at Homestake's property boundary to create a barrier to the migration of groundwater with elevated selenium from the property boundary and move contaminant concentrations back towards the tailings facility. Homestake also installed a system of collection wells immediately downstream of the tailings pile that were designed to collect seepage from the tailings pile as well as to retrieve groundwater that may already have migrated from the pile. The system was installed between 1977 and 1982.

In 1981, the U.S. Environmental Protection Agency (US EPA) proposed that the Grants Mill be placed on the Superfund list. Homestake and EPA subsequently entered into an agreement which required Homestake to pay for the extension of the Milan, New Mexico, municipal water system to supply potable water to four of the residential subdivisions near its mill. Homestake also agreed to pay basic water service charges for the residents of these subdivisions for 10 years. Finally, Homestake agreed to continue the groundwater injection and collection programs to assist in groundwater cleanup.

Since that time, groundwater remediation has continued and been modified in response to monitoring results. A bullet summary of the key milestones of the groundwater restoration program (which evolved into the current groundwater CAP) is as follows:

- 1976 - Agreement between New Mexico Environmental Department and Homestake on a Corrective Action Program. This pre-dates the Discharge Plan program.
- 1977 – Fresh water injection into six alluvial wells on the north side of Broadview Acres was initiated (the G line).
- 1978 - The S and D line collection wells were installed. Significant problems due to calcite precipitate were encountered in maintaining yields from wells until an inhibitor was used on the collection wells to maintain yields.
- 1980 - Start of Murray Acres collection program by pumping two alluvial wells.
- 1981 - Two additional Murray Acres collection wells were added.
- 1982 - Additional collection wells were added on the D collection line. Eleven injection wells were also added on the north side of Broadview Acres, extending the fresh water injection line to the east along the G line injection wells.

- 1983 - The M injection line was added on the north side of Murray Acres.
- 1984 - Injection into Upper Chinle well CW5 was initiated. Hearings on and approval of discharge plan DP-200 occurred.
- 1986 - Installation of the Milan water supply for Broadview, Felice, Murray Acres, and Pleasant Valley estates subdivisions.
- 1989 - Renewal of DP-200. NRC Corrective Action Plan was developed.
- 1990 - The Murray Acres collection system was modified by closing well AW and adding collection wells E, Z and JC. Injection well AW (Murray Acres) and wells GW1, GW2 and GW3 (north of Broadview Acres) were added to the injection system. Use of the No. 1 Evaporation Pond started in November.
- 1992 - Toe drains were installed around the tailings.
- 1993 - The last two Murray Acres collection wells were turned off and three wells in the K line were added to the collection program. The upgradient P wells started pumping the upgradient alluvial water and transferring it to the drainage to the west. The west side of the Large Tailings pile was re-contoured. The GW injection wells ceased operation in early May and the start of the J injection line occurred.
- 1994 - Additional K line wells were added. The east side of the Large Tailings pile was re-contoured.
- 1995 and 1996 – Additional downgradient wells were drilled in the alluvial and Chinle formations.
- 1995 - Collection of lower concentration water for re-injection into the higher concentration areas in the alluvial aquifer was started. Tailings dewatering of the Large Tailings pile was initially tested. The C collection wells were initially used. Injection into Upper Chinle well CW5 ceased in mid-May.
- 1996 - The M injection line was extended to the north. Usage of the No. 2 Evaporation Pond began in March. Fresh water injection started in Upper Chinle well CW13.
- 1997 - Injection into Upper Chinle well CW5 resumed. Injection into Middle Chinle well CW14 was initiated in December. Additional M injection wells were installed.
- 1998 - Injection into Murray Acres well AW ceased in May. Additional upgradient collection wells were added.
- 1999 - The reverse osmosis unit was added to treat water and produce R.O. product water for injection into the alluvial aquifer. Upper Chinle well CE2 collection was initiated.
- 2000 - The M injection line was moved to the WR injection line. Initiation of irrigation of 270 acres was started. Injection into Upper Chinle well CW25 started. The flushing program for the Large Tailings Pile began.
- 2002 - 60 acres of irrigation area were added. Fresh water injection started in Section 28. Fresh water injection into Upper Chinle well 944 was initiated. Fresh water injection into the alluvial aquifer east of Felice Acres was initiated. Fresh water injection east of Broadview Acres was initiated.
- 2003 – The fresh water injection line west of the Large Tailings Pile was added. Fresh water injection into Section 3 was initiated.

- 2004 - 24 acres of flood irrigation area were added in Section 33. Injection lines were added in Section 3. Injection lines were added east of Broadview Acres and in southern Felice Acres.

- 2005 – 40 acres of irrigation were added to the Section 28 center pivot. The S injection line west of the Large Tailings Pile was extended to the north. Freshwater injection lines NP1 - NP8 were added in Sections 27 and 28. Injection into NP1 – NP6 was initiated. Three freshwater injection lines were added to the east of the Large Tailings Pile. Freshwater injection lines EBA3 – EBA5 were added near the L collection line. Injection lines EMA1 – EMA5 were added to the south and west of the Large Tailings Pile. Freshwater injection into EMA1 and RO product water into EMA2 – EMA5 was initiated.

Figures 3 through 8 illustrate groundwater remedial activities for six different time periods starting in 1978 up through 2005.

2.4 Geologic and Hydrologic Setting

A great deal of work has been done over the last 40 years to understand the regional and local geologic conditions. Much of that information is summarized in the "Background Water Quality Evaluation of the Chinle Aquifer" report (Homestake and Hydro-Engineering, 2003). Some of that information is relevant to understanding the groundwater CAP and is repeated here.

Figures 9 and 10 present portions of the geologic map of the Grants quadrangle (Dillinger, 1990). The eastern limit of Figure 9 joins the western limit of Figure 10. These two figures show the geologic outcrops and the San Mateo Creek and Lobo Creek drainages. The San Mateo Creek drainage basin is 240 square miles at the northern edge of the Large Tailings Pile, while the Lobo Creek drainage area is 56 square miles. Lobo Creek joins San Mateo Creek at the Grants site. Neither creek has a well-defined channel, and surface flow is infrequent at the site. Upgradient well R is shown on Figure 9 as a reference location for other figures. The grid lines on Figures 9 and 10 are one mile apart.

The uranium-ore-bearing rocks that have been mined in this area are Jurassic rocks and are shown with the "Ju" symbol. Figure 11 presents the geologic index for Figures 9 and 10. The ore-bearing rocks are mainly the Westwater Canyon Sandstone Member of the Morrison formation and the Todilto Limestone, the bottom member of the Wanakah formation. A significant area of outcrop of these units exists north of the Grants site both in the San Mateo and Lobo Creek drainages. Kelly (1963) and Rautman (1980) present the details of geology of uranium production in this area.

Production of uranium started in the 1950s in the underground mines in the Ambrosia Lake area. The majority of the production from this area was from the Ambrosia Lake mines. The alluvial systems in this area were produced from erosion of the bedrock materials in the drainage basin. Therefore, the

alluvial material would be expected to contain above normal concentrations of uranium, selenium and molybdenum, constituents that are typically present in uranium deposits. The Chinle formation outcrops in a small portion of the drainage basin, but subcrops beneath a larger percentage of the San Mateo Creek drainage. The Chinle formation has been shown to contain significant natural levels of uranium and selenium.

The uppermost aquifer at Grants site is the San Mateo alluvial system. The alluvial aquifer system follows the San Mateo drainage. The alluvial aquifer beyond the Grants site includes the saturated portion of the San Mateo downgradient of the site, and the Lobo Canyon and Rio San Jose alluviums. San Mateo Creek is a tributary to the Rio San Jose drainage while Lobo Canyon is a tributary to the San Mateo. The alluvial aquifer is present from northeast of the Grants site, through the site and continuing to the south and to the west.

Beneath the Grants site, the Chinle Formation lies under the alluvium. The Chinle Formation is a massive shale, approximately 800 feet thick. The shale is a very effective aquitard and greatly restricts vertical groundwater flow from the overlying alluvial aquifer. Sandstone units are found within the Chinle shale and these sandstones form aquifers in this area. The sandstone unit closest to the ground surface has been named the Upper Chinle aquifer. A typical north-south cross section (Figure 12) shows the Upper Chinle sandstone in blue and illustrates the contact between the Upper Chinle sandstone and the alluvium in the subcrop area.

The second major continuous sandstone unit in the Chinle Formation is the Middle Chinle. This sandstone is shown in red in the cross section and subcrops beneath the alluvium further to the south.

As shown on Figure 12, the deepest permeable zone within the Chinle shale is the Lower Chinle aquifer. The Lower Chinle aquifer is located approximately 200 feet above the base of the Chinle Formation and consists mainly of fractured shale rather than continuous sandstone. Hence, the hydraulic properties are largely dependent on secondary permeability within the shale. The ability of the Lower Chinle aquifer to produce water is much lower and less consistent than in the overlying Middle and Upper Chinle sandstone aquifers.

The San Andres aquifer underlies the Chinle Formation at a depth of greater than 800 feet from the surface at the Grants site. This is the regional aquifer in the area. Details for the San Andres aquifer are not presented in this report because it has not been affected by seepage from the Grants site.

2.4.1 San Mateo Alluvium

The San Mateo alluvial aquifer underlies the tailings impoundment and is the uppermost aquifer in the groundwater system. The areal extent of the alluvial aquifer is indicated on Figure 13.

The alluvial aquifer is an unconfined aquifer with the water table approximately 50 feet below the ground surface in the tailings impoundment area. The bottom of the aquifer is defined by the contact of the alluvial formation with the Chinle formation.

2.4.1.1 Alluvial Aquifer Properties

HMC has drilled more than 700 wells at the Grants site. The geophysical and lithologic logs from these wells, as well as logs and information for residential wells not owned by HMC, have been used to define the base of the alluvium. The contours of the base of the alluvium are shown on Figure 14. The deepest portion of the alluvial aquifer is present below the western portion of the Large Tailings Pile. It turns to the southwest near the southwest corner of the Large Tailings Pile. The land surface elevation in this area is at approximately 6,580 feet MSL, so the alluvium, at its thickest point, extends 120 feet below the ground surface.

The elevation of the base of the alluvium is shallower in an area extending from the eastern Murray Acres subdivision to the Small Tailings Pile. In this area, the alluvium is approximately 60 feet thick. The reduction in saturated thickness and a generally lower permeability of the alluvial material in this area combine to decrease the rate of alluvial flow. The boundary of the alluvial aquifer is defined where the elevation of the base of the alluvium is equal to the water-level elevation (see green line on Figure 14).

A significant area of zero saturation also exists in southern Felice Acres, which extends to the west through Section 34 due to higher elevations in the base of the alluvium. The elevation to the base of the alluvium also increases on the south side of this figure with a limit of saturation in the southern portion of the map.

The difference between the water-level elevation and the base of the alluvium produces the saturated thickness of the alluvial aquifer as presented in Figure 15. This figure shows that the saturated thickness is slightly more than 60 feet southwest of the Large Tailings Pile and decreases to zero at the edge of the alluvial aquifer. The cross-sectional area available for conveyance is proportional to the aquifer thickness, which makes the thickness important in defining the transmitting capacity of the aquifer.

The transmitting ability of an aquifer is defined by the transmissivity and the hydraulic conductivity (permeability). Transmissivity is the total transmitting ability of the aquifer, while permeability is the

unit thickness transmitting ability of the aquifer. Hydraulic conductivity is a representation of the permeability with water as the assumed fluid and, thus, can be used interchangeably with permeability for groundwater flow. The specific yield is the primary storage property for the unconfined alluvial aquifer, while the storage coefficient is the important storage parameter for the confined bedrock aquifers. A summary of the aquifer properties for each of the aquifers is presented in Hydro-Engineering (1996). Figure 16 presents the transmissivity of the alluvial aquifer in gallons per day per foot. Transmissivities for the alluvial aquifer near the Grants site vary over a wide range from higher than 40,000 gal/day/ft to less than 1,000 gal/day/ft. Typically, the main portion of the San Mateo alluvial channel exhibits transmissivities higher than 10,000 gal/day/ft. Due to aquifer thinning, transmissivities decrease toward the unsaturated zone on the edges of the alluvial channel. Transmissivities increase in the western half of Section 27 to more than 50,000 gal/day/ft.

Hydraulic conductivity varies substantially in the San Mateo alluvial aquifer. Figure 17 presents the hydraulic conductivity of the alluvial aquifer at the Grants site. A hydraulic conductivity greater than 20 feet per day is typical of the main portion of the San Mateo alluvial system. Some permeabilities for this system are less than one foot per day but the permeability increases to more than 200 ft/day in the western portion of Section 27. Specific yields for this site have varied from 0.038 to 0.28. A specific yield of 0.2 is thought to best represent the alluvial aquifer at the Grants site.

2.4.1.2 Alluvial Groundwater Flow

The direction of groundwater flow is governed by the piezometric surface and aquifer properties of the aquifer. The gradient of this piezometric surface, the hydraulic conductivity and specific yield all affect the rate that the groundwater actually moves.

The water-level elevation for the alluvial aquifer is presented in Figure 18. Figure 18 shows the major flow paths for the alluvial aquifer. The San Mateo alluvial system flows into the Grants site area from the north and northeast and flows to the west and southwest through Murray Acres and Pleasant Valley before joining the Rio San Jose alluvial system in the western portion of Section 28. This alluvial system also flows around the east side of Felice Acres into Section 3 and joins the Rio San Jose further downgradient. Locally, flows have been reversed between the injection and collection systems due to the mounds and depressions imposed on the piezometric surface.

The groundwater upgradient of the Large Tailings Pile is moving at an average rate of 0.5 feet per day based on a gradient of 0.0033 ft/ft, a permeability of 30 feet per day and an effective porosity of 0.2. To

the southwest of the Murray Acres injection system, groundwater is estimated to be moving at a rate of 0.7 feet per day.

The flow of the San Mateo alluvial system north of the Grants site has been estimated to be between 58 and 62 gpm. Under the injection conditions that have occurred for over 20 years, the quantity of water moving southwest and west from the Grants mill site is estimated to be 260 gpm. An estimate of 69 gpm was obtained for the area to the south of Broadview Acres. This indicates that approximately 330 gpm is moving downstream of the Grants site. Approximately 70 gpm is flowing in the Section 3 area.

2.4.2 Upper Chinle

The Upper Chinle aquifer is an important groundwater system at the Grants site because of the direct communication between the groundwater in the alluvium and this aquifer in the subcrop area shown on Figure 19. The degree of hydraulic communication in the subcrop area influences the water quality of the Upper Chinle aquifer because the subcrop extends below the alluvium under the Large Tailings Pile. The Upper Chinle aquifer is the uppermost sandstone in the Chinle Formation in this area and is shown in blue on the cross section figures (Figure 12). This sandstone varies from a few feet up to 40 feet in thickness.

The elevation of the top of the Upper Chinle aquifer and the base of the alluvial aquifer define where these two aquifers are in direct communication. Two faults (West and East) extend through the Grants site and are also significant in defining the extent of the Upper Chinle aquifer.

The areal extent of the Upper Chinle aquifer and locations of wells completed in the Upper Chinle aquifer are shown on Figure 19. The Upper Chinle also exists in its subcrop area where it is in direct contact with the alluvium. Except in the subcrop area, the Chinle shale separates the alluvium and the Upper Chinle sandstone. The Upper Chinle does not extend to the west of the West Fault, but subcrops against the alluvial aquifer on its western and southern borders.

Contours of the elevation of the top of the Upper Chinle aquifer are shown in Figure 20. This figure illustrates that the Upper Chinle sandstone between the two faults generally dips to the east. East of the East Fault, the general dip is also to the east. On the south side of the Grants site, the top of the Upper Chinle sandstone dips to the northeast with a steeper gradient, and it subcrops beneath the alluvium in the area of southern Felice Acres.

The transmissivity of the Upper Chinle aquifer can be very high in areas where it is highly fractured. Values greater than 10,000 gal/day/ft are typical of the Upper Chinle in those areas where it is highly

fractured. This aquifer is highly fractured in the area between the Small Tailings Pile and Broadview Acres and close to the East Fault on the east side of the East Fault. These high transmissivity zones are both limited to within several hundred feet on both sides of the East Fault. The transmissivities of the Upper Chinle aquifer are very low on its western side between the two faults where it is not fractured. The transmissivity of the Upper Chinle aquifer is much lower on its west side in its subcrop area due to its finer grain size and less fracturing in this area.

A typical permeability for the Upper Chinle of seven feet per day is thought to be representative of this unit except in the area where it is highly fractured. A permeability of 100 feet per day is more representative of the Upper Chinle aquifer in these highly fractured zones such as those represented by wells CW4R, CW5 and CW13, which is between the Small Tailings Pile and the Broadview Acres area.

2.4.3 Middle Chinle

The Middle Chinle aquifer is significant because direct communication between this aquifer and the alluvium occurs in the subcrop area near the south edge of the Felice Acres subdivision. The areal extent of the subcrop of the Middle Chinle aquifer is significantly smaller than that for the Upper Chinle aquifer, and the subcrop is located a greater distance from the Grants site. However, there are detectable impacts in the alluvial aquifer in the area of the Middle Chinle aquifer subcrop. Because the subcrop for the Middle Chinle is further from the source than the subcrop for the Upper Chinle aquifer, the Middle Chinle aquifer is less affected than the alluvial aquifer or the Upper Chinle aquifer.

The Middle Chinle aquifer is generally the thickest of the sandstone units in the Chinle Formation, reaching a thickness of up to 40 feet in some locations. Figure 12 shows a typical north-south cross section of the alluvial and Chinle aquifers in this area, with the Middle Chinle aquifer shown in red. This figure shows Chinle shale present between the Upper Chinle and the Middle Chinle sandstone units. In addition to the subcrops in the Felice Acres area, the Middle Chinle sandstone subcrops against the alluvial aquifer in some areas of the Grants site to the west of the West Fault which is west of the Large Tailings Pile.

The areal extent of the Middle Chinle aquifer and the Middle Chinle well locations are shown on Figure 21. Patterns in red depict the Middle Chinle sandstone and its associated aquifer. The Middle Chinle sandstone extends to the west of the West Fault in a limited area and is present more extensively east of the West Fault.

The elevation contours of the top of the Middle Chinle sandstone are provided in Figure 22. This structure map shows the elevation of the top of the Middle Chinle sandstone on each side of the two faults

in the area of the Large Tailings Pile. The displacement of the sandstone unit due to faulting results in three discontinuous sandstone units. Multi-well pump tests in the Middle Chinle aquifer have shown that two of the three sandstone units of the Middle Chinle aquifer in this area act as separate fault-bound aquifers. The exception is the Middle Chinle aquifer near the southern end of the East Fault where there is little or no displacement of the sandstone.

The Middle Chinle sandstone dips at a steeper angle in southern Felice Acres, and, therefore, the Middle Chinle sandstone subcrops against the alluvium on the south side of Felice Acres. In this subcrop area, direct communication exists between the Middle Chinle and the alluvial aquifers and as a result alluvial water has influenced the water quality in the Middle Chinle aquifer in and immediately adjacent to the subcrop area. Transmissivities for the Middle Chinle aquifer typically range from 5,000 to 7,000 gal/day/ft. The average permeability of the Middle Chinle aquifer near the Grants site is approximately 25 feet per day. A storage coefficient of $3x10^{-5}$ is thought to best represent the Middle Chinle aquifer.

2.4.4 Lower Chinle

The Lower Chinle aquifer is important because direct communication occurs between this aquifer and the alluvium in the subcrop area to the southwest of the Grants site. However, the potential for impacts to the Lower Chinle aquifer is significantly reduced because the subcrop is a large distance from the Grants site. Also, the natural water quality of the major constituents in the shaly Lower Chinle aquifer is poor so there is generally less use of this aquifer as a water source. Water quality in the Lower Chinle is poor because of the low permeability of the shale and the associated long residence time for groundwater.

The Lower Chinle aquifer is the deepest permeable zone in the lower portion of the Chinle Formation. The Lower Chinle aquifer is not a sandstone unit, like the Upper and Middle Chinle aquifers. Instead, higher permeability in portions of the Chinle shale is adequate in some locations to allow this zone to function as an aquifer. The primary factor determining the permeability in the Lower Chinle is secondary permeability associated with fracturing. A typical north-south cross section of the aquifer system in this area is shown on Figure 12. This figure shows the Lower Chinle aquifer as discontinuous because the permeability is not consistently high enough to function as a viable aquifer. Therefore, areas exist in the Lower Chinle where the aquifer is effectively absent.

The areal extent of the Lower Chinle aquifer is shown on Figure 23. The cyan pattern shows where the Lower Chinle aquifer is present. The Lower Chinle aquifer is continuous on both sides of the East Fault south of the area where this fault terminates. Therefore, in the main area of interest in the Lower Chinle, the aquifer functions as a single hydrologic unit on both sides of the East Fault. The Lower Chinle also

extends to the west of the West Fault. South of the Grants site, the Lower Chinle subcrops against the unsaturated alluvium to the east and the alluvial aquifer to the west. The subcrop area occurs where the top of the Lower Chinle aquifer intersects the base of the alluvial aquifer.

The two faults significantly alter the Lower Chinle structure in the Grants site tailings impoundment area. As with the other two Chinle aquifers, numerous cross sections have been developed to correlate geophysical logs in Lower Chinle drill holes and wells. These cross sections were subsequently used in developing the structure maps. Elevations of the top of the Lower Chinle aquifer are shown in Figure 24. The Lower Chinle aquifer between the two faults and near the tailings piles generally dips to the east. West of the West Fault, the general dip is also to the east. However, on the south side of the Grants site, the Lower Chinle dips to the north-northeast at a steeper gradient, such that the unit subcrops at the base of the alluvium in areas of Sections 3, 4, 28, 33 and 34 as previously described.

Aquifer properties of the Lower Chinle aquifer vary over a wide range. Transmissivity of the Lower Chinle aquifer has been determined to range from less than 20 to 1590 gal/day/ft. Other than the HMC wells, only two or three wells completed in the Lower Chinle aquifer are being used. The Lower Chinle aquifer is only usable as a water source in the areas near its subcrop with the alluvium, where adequate secondary permeability has resulted from weathering and faulting.

The permeability of the Lower Chinle aquifer varies from less than 0.1 to slightly greater than 4 ft/day. The storage coefficient of the confined Lower Chinle aquifer varies from 3.4×10^{-5} to 1.2×10^{-4}. The specific yield for the Lower Chinle aquifer is estimated to be less than 0.1.

2.4.5 Bedrock Groundwater Flow

Figure 25 presents the current flow paths for the alluvial and Upper Chinle aquifers. Groundwater in the Upper Chinle between the two faults is flowing to the south. The fresh water injection into CW5 is causing Upper Chinle water to flow back towards the Grants site and to the south in Broadview and Felice Acres. Groundwater flow in the Upper Chinle east of the East Fault is outward from injection well CW13. The East Fault is a barrier to groundwater flow in the Upper Chinle aquifer and, therefore, allows independent flow in the Upper Chinle aquifer on each side of the fault. The majority of the flow in the Upper Chinle east of the East Fault would be in the high transmissivity zone paralleling the East Fault. Some groundwater is moving east into the less transmissive portion of the aquifer. The groundwater gradient in the Upper and Middle Chinle aquifers is generally very flat. The Upper Chinle sandstone subcrops on the west edge and to the south of the Grants site. The Upper Chinle subcrop extends from

the Large Tailings Pile into the eastern edges of Murray Acres. Therefore, the area of the Upper Chinle that is most important occurs at the northeast corner of Murray Acres.

Figure 26 shows the groundwater flow paths for the alluvial and Middle Chinle aquifers and shows that the flow in the Middle Chinle aquifer is to the northeast between the two faults as well as east of the East Fault except for the change in flow direction due to the CW14 injection to the northwest of Broadview Acres. The Middle Chinle is saturated in a narrow band west of the Large Tailings Pile on the west side of the West Fault. Groundwater in this portion of the Middle Chinle is flowing to the southwest and discharging into the alluvial aquifer at its subcrop with the overlying alluvium. The gradient in the Middle Chinle aquifer is highly variable in this area due to variations in transmissivity. The faults also retard movement in the Middle Chinle aquifer across the faults.

Water level elevation information and flow directions for the Lower Chinle aquifer are presented on Figure 27. Flow west of the West Fault in the Lower Chinle is mainly to the northeast. Flow between the two faults is to the northwest and north, indicating that the flow of some Lower Chinle water is uninterrupted by the West Fault.

A comparison between the alluvial and the Lower Chinle aquifers shows that water level elevations in the alluvial aquifer are higher than those of the Lower Chinle. The exception to this is in the subcrop areas where the hydraulic communication between the two aquifers results in very similar heads. Across the site, the head differential indicates that the only communication between the alluvial and Lower Chinle aquifers is in these isolated subcrop areas.

2.5 Backgroundwater Quality

A comprehensive backgroundwater quality evaluation has recently been conducted and was submitted to NRC in October 2003 (revised June 2004) (Homestake and Hydro-Engineering 2004). This document defines backgroundwater quality in the alluvial aquifer, as well as in the Upper, Middle and Lower Chinle aquifers. It also defines a separate backgroundwater quality for the Chinle Mixing Zone.

It should be noted that baseline water quality in the alluvial aquifer may change in the future. Discharge of groundwater from past mine dewatering in Ambrosia Lake area (north and upgradient of the site) to the San Mateo alluvial aquifer had elevated levels of the same constituents as are elevated in the Grants tailings impoundments. Travel time calculations and preliminary information from far upgradient wells indicates selenium, uranium and other constituents from mine discharges to the alluvial aquifer could reach the Grants site in the next 20 years. Therefore it will be necessary to continue to monitor

upgradient water quality to determine whether potential impacts and changes in backgroundwater quality results from past activities upgradient of the Grants site.

2.6 Hazardous Constituents

The background evaluation, along with consultation with the State and US EPA, has resulted in the finalization of site groundwater standards for each constituent and each aquifer. Standards were set at background or drinking water standards, whichever was greater. Table 2-1 presents the standards for each constituent and each aquifer as approved in License Amendment No. 39.

Table 2-1 Site Groundwater Standards

Constituent	Alluvial	Chinle Mixing Zone	Upper Chinle Non-mixing Zone	Middle Chinle Non-mixing Zone	Lower Chinle Non-mixing Zone
Selenium (mg/L)	0.32	0.14	0.06	0.07	0.32
Uranium (mg/L)	0.16	0.18	0.09	0.07	0.03
Molybdenum (mg/L)	0.10	0.10	0.10	0.10	0.10
Sulfate (mg/L)	1500	1750	914	857	2000
Chloride (mg/L)	250	250	412	250	634
TDS (mg/L)	2734	3140	2010	1560	4140
Nitrate (mg/L)	12	15	*	*	*
Vanadium (mg/L)	0.02	0.01	0.01	*	*
Thorium-230 (pCi/L)	0.30	*	*	*	*
Ra-226+Ra-228 (pCi/L)	5	*	*	*	*

*Site standards not necessary for the constituents in the indicated aquifer

2.7 Groundwater Monitoring and Current Conditions

Groundwater monitoring has been conducted since 1975. The most recent groundwater monitoring report was submitted to the NRC in March 2006 and includes the groundwater monitoring data for 2005. The results of the groundwater monitoring indicate that the water quality in the aquifers is improving as the corrective action program has progressed at the Grants site.

2.8 Surrounding Land and Groundwater Use

An update of the surrounding land and groundwater use was included as Appendix E in the most recent annual monitoring report dated March 2006 (Homestake and Hydro-Engineering, 2006). This report documented the surrounding land use and concluded that all of the adjacent residences in Broadview, Felice, Murray, and Pleasant Valley subdivisions are being supplied domestic water by the Village of Milan. The Village of Milan water was first supplied to these subdivisions in 1986. At a later date, the Milan water supply was extended out to the Valle Verde subdivision and residents immediately east of Valle Verde. Current information indicates that eleven residents in this area may still use well water for their drinking water supply.

3.0 DESCRIPTION OF REVISED CAP

The Revised CAP is a result of modifications to the groundwater corrective action operations over the last 29 years and incorporates lessons learned regarding the hydrologic and geochemical responses observed in each aquifer system. The program will continue to evolve in response to changing site conditions. Figure 28 presents a flow diagram that summarizes the current major components of the Revised CAP. The Revised CAP (as per 2005 activites) is discussed below, based on the annual reporting presented to US NRC (Homestake and Hydro-Engineering, 2006). The Revised CAP is comprised of 15 major elements; these elements are organized and discussed in the subsections below.

The Revised CAP is expected to evolve or change in the future in response to changing site conditions and reclamation activities. The subsections below also outline anticipated future activities for these major elements.

3.1 Tailings Extraction Wells

In 2005 there were 140 wells in the Large Tailings Pile that are used as extraction wells. Approximately 87 gpm was extracted from the tailings, and of that total, approximately 81 gpm with the highest TDS concentrations is pumped directly to the evaporation ponds. The remaining 6 gpm was routed to the RO plant. Figure 29 shows the location of the tailings extraction wells. This extraction program is expected to continue through 2012.

3.2 Tailings Injection Wells

Approximately 155 wells completed in the Large Tailing Pile were used as injection wells in 2005. Approximately 233 gpm was injected into the tailings to flush out constituents. Water for injection was obtained from the alluvial, Upper Chinle and Middle Chinle aquifers. Figure 29 shows the location of the injection wells. The tailings injection program is expected to continue through 2011.

3.3 Tailings Toe Drain

Toe drains were installed along the perimeter of the Large Tailings Pile to collect tailings porewater and route it to the evaporation ponds. Approximately 40 gpm was collected from the toe drains in 2005. The location of the toe drains are shown on Figure 29. Porewater collection from the toe drains is expected to continue through 2012.

3.4 Alluvial Aquifer Extraction Wells

Seventy-five wells in the alluvial aquifer are being used as extraction wells and a total of approximately 780 gpm was pumped from the alluvial aquifer in 2005. Some of the water (approximately 455 gpm[1]) was routed to the irrigation system (Section 3.15). Approximately 250 gpm was routed to the RO treatment plant. Approximately 40 gpm of upgradient clean water was pumped and discharged to surface to reduce flow under the tailings impoundment. The remainder was re-injected into the tailings impoundment (5 gpm) or into more contaminated areas in the alluvial aquifer (34 gpm).

The water disposed of in the irrigation system has a uranium concentration of less than 0.44 mg/L and less than 0.12 mg/L selenium. Most of the water being used in the irrigation system currently is obtained from areas farther south and west of the Grants site as shown on Figure 30.

Water with relatively high concentration of constituents is routed to the RO treatment plant. In 2005, approximately 250 gpm was pumped from the alluvial aquifer for treatment in the RO plant. The wells currently being pumped to the RO plant are shown on Figure 30 (labeled as RO collection wells).

Some of the water extracted from the alluvial aquifer is being re-injected into the tailings and into other areas in the alluvial aquifer to aid in the removal of constituents from areas with higher concentrations. Approximately 39 gpm from the alluvial aquifer was re-injected in 2005. The locations of the wells used for re-injection are shown on Figure 30 (labeled as collection wells for re-injection).

Uncontaminated alluvial water from an upgradient well is pumped to reduce the flow into the contaminated area. This water is pumped at a rate of approximately 40 gpm and is discharged to the surface (labeled in Figure 30 as upgradient collection wells).

Alluvial groundwater extraction is expected to continue through 2015.

3.5 Alluvial Aquifer Injection Wells/Trenches

Water is being injected into the alluvial aquifer to aid in flushing, and to provide hydraulic barriers in the alluvial aquifer. There were 115 injection wells and approximately 5,000 lineal feet of injection line being used in the alluvial aquifer in 2005. The location of these injection wells and lines are shown on Figure 30. Approximately 198 gpm of treated water from the RO plant was injected in 2005, primarily around the Small Tailings Pile. The remainder of the injection water, approximately 1,150 gpm, was obtained from the San Andres formation, the alluvial aquifer, and the Upper Chinle and was injected into

[1] This pumping rate is an annual average rate. Pumping to the irrigation system occurred at approximately 682 gpm for 8 months during 2005.

wells and injection lines shown on Figure 30. Alluvial water injection is expected to continue through 2015.

3.6 Upper Chinle Extraction Wells

Four wells completed in the Upper Chinle formation pumped approximately 142 gpm of water in 2005. This water was re-injected into the tailings pile (127 gpm), routed to the irrigation system (10 gpm) and used to flush the alluvial aquifer (5 gpm). The extraction wells are shown on Figure 31.

3.7 Upper Chinle Injection Wells

Fresh water was being injected into the Upper Chinle in five wells. The water for this injection was obtained from the San Andres aquifer. A total of approximately 57 gpm was injected into the aquifer in 2005. The locations of the injection wells are shown on Figure 31. Injection into the Upper Chinle formation is expected to continue through 2009.

3.8 Middle Chinle Extraction Wells

Water is being pumped from eight wells completed in the Middle Chinle formation. Water from five of these wells is used to supply the irrigation system, with the annual average rate supplied being approximately 101[2] gpm in 2005. The remaining wells are used as supply wells for reinjection into the tailings and alluvial aquifer. Approximately 101 gpm was extracted from the Middle Chinle in 2005 for injection into the tailings. The current extraction wells are shown on Figure 32.

3.9 Middle Chinle Injection Wells

Fresh water is being injected into the Middle Chinle in three wells; the water for this injection is obtained from the San Andres aquifer. A total of approximately 46 gpm was injected into the aquifer in 2005. The locations of the current injection wells in the Middle Chinle aquifer are shown on Figure 32. Injection into the Middle Chinle formation is expected to continue through 2009.

3.10 Lower Chinle Extraction Well

There are currently three extraction wells in the Lower Chinle formation, and water from these wells is used for irrigation supply. Approximately 75 gpm[3] was pumped in 2005. The locations of these wells are shown on Figure 33.

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[2] This pumping rate is an annual average rate. Pumping to irrigation system occurred at approximately 152 gpm for 8 months during 2005.

[3] This pumping rate is an annual average rate. Pumping to irrigation system occurred at approximately 86 gpm for 8 months during 2005.

3.11 Lower Chinle Injection Wells

There are currently no injection wells in the Lower Chinle formation.

3.12 Reverse Osmosis (RO) System

The RO treatment plant was designed and constructed in 1999, and has been used to treat water from the tailings and alluvial aquifer with the highest concentrations of constituents. The RO treatment plant is comprised of two separate treatment trains, each with a capacity of 300 gpm.

In 2005, the RO plant received approximately 256 gpm from the tailings and alluvial aquifer. Approximately 198 gpm of treated water was produced for re-injection as discussed above. The remaining 49 gpm is brine, which was discharged to the lined evaporation ponds. RO treatment plant operations are expected to continue (under current conditions) through 2015.

3.13 Evaporation Ponds

There are two lined evaporation ponds with a total area of approximately 43.8 acres. The ponds are used to evaporate approximately 49 gpm brine from the RO treatment plant and 121 gpm from the tailings impoundment in 2005. Spray evaporation is used to enhance the total evaporation rate. The evaporation ponds are regulated by New Mexico Discharge Plan DP-725.

An additional evaporation pond is scheduled for construction in 2007. Evaporation pond operation is expected to continue through 2015.

3.14 Clean Water Extraction Wells

Clean water is obtained from wells completed in the San Andres formation and from the un-impacted areas of the alluvial aquifer. Extraction wells in the San Andres are shown on Figure 34. An average of approximately 1,253 gpm was being pumped from these wells in 2005 and injected into the alluvial, Upper Chinle and Middle Chinle aquifers. These wells will be pumped on a schedule consistent with the various aquifer injection programs described above.

3.15 Irrigation System

Groundwater with slightly elevated levels of constituents is used in the irrigation system. The irrigation system consists of two flood irrigation areas consisting of 120 and 24 acres. There are also two center-pivot irrigation areas consisting of 100 acres and 150 acres. The locations of the irrigation areas are shown on Figure 35. A total of 1034 acre feet of water was applied to these areas in 2005; this is equivalent to the average annual total rate of 641 gpm from the alluvial, Middle Chinle and Lower Chinle aquifers. The total application rate for the eight month growing season was approximately 961 gpm.

Land application of water was reviewed and approved by the NRC and the State through letter authorizations, and is an important component of the Revised CAP. The maximum constituent levels for uranium and selenium are currently set at 0.44 mg/L and 0.12 mg/L, respectively, for land application of groundwater. The irrigation program is expected to continue (under current conditions) through 2105.

3.16 Summary of Performance to Date

The groundwater corrective actions have resulted in significant restoration of groundwater quality in the impacted aquifers. Results from the groundwater monitoring wells have been submitted to the NRC on an annual basis and show that the current CAP activities are performing well and that the concentrations are approaching the proposed regulatory limits. Improvement in water quality can best be seen on plots of the extent of plumes for the major constituents for each aquifer. Figures 36 through 46 show the change in the extent of contamination for uranium, selenium, and molybdenum for each of the four aquifers. There is no figure showing changes in molybdenum concentrations in the Lower Chinle, as this aquifer has never had elevated molybdenum levels.

Significant progress has been made in the alluvial and Upper Chinle aquifers. Additional restoration is needed, with particular focus on the Middle Chinle aquifer over the next several years.

3.17 Groundwater Modeling

The current CAP includes more than 220 extraction wells, more than 240 injection wells and trenches, a RO treatment plant and almost 400 acres of area for irrigation. The current program has been modified since 1977 as site conditions have changed and additional monitoring data have been collected. The future CAP requirements must be sufficiently flexible to allow elements of the CAP to change to optimize efficiencies and meet applicable water quality cleanup objectives.

A numerical flow model and transport model were developed for the Grants site to predict the length of the groundwater restoration program (presented in Appendix C). A tailings seepage model (which takes into account the use of tailings porewater extraction wells through year 2012) was used as an input to the groundwater model. The numerical model predicts that the groundwater restoration program will need to extend through 2015 to meet current site standards at the points of exposure.

3.18 Future CAP Operations

Based on the performance of the CAP and the groundwater modeling summarized in Section 3.17, it is anticipated that the CAP will be necessary in some form through 2017. An estimate of the future CAP elements is presented on Figures 47 and 48. Actual duration of the CAP and the individual elements of the CAP will be dependent upon future system performance.

Homestake understands that it is necessary to commit to minimum requirement to allow for license compliance. It has been observed that minimum extraction rate of 200 gpm, minimum injection rate of 300 gpm and minimum irrigation rate of 400 ac-ft/yr lead to improving water quality. Several key elements of the future corrective action are necessary to move towards compliance with the proposed standards at the POC wells, specifically: total injection rates, extraction rates, and total amount of irrigation water. Actual wells used for extraction and wells or trenches used for injection will be modified based on the real time performance of the system.

The key elements of the Revised CAP are related to total injection rates, extraction rates, and the total amount of land application/irrigation water use . Actual wells used for extraction and wells or trenches used for injection and associated rates of extraction or injection in the future will be modified based on the performance of the system as determined by ongoing monitoring to assure that the objectives of the CAP achieved. Changes and modifications to the operational rates for these CAP elements will be documented and reported in the Annual Performance Reviews required under the US NRC Radioactive Materials License.

4.0 MONITORING PROGRAM

A comprehensive groundwater monitoring program is currently in place and will be maintained at the site. The monitoring program will consist of monitoring point-of-compliance (POC) wells and several additional monitoring wells. The POC wells will continue to be used as the points where the approved groundwater standards are to be met. The POC wells are near the edge of the reclaimed tailings impoundments and are completed in the alluvial aquifer, which is the upper-most aquifer.

Additional monitoring wells will be used to monitor water quality in all of the impacted aquifers and will generally be downgradient from the POC wells. The compliance monitoring wells will be used to measure performance of the CAP and to aid in modifying the CAP to improve groundwater capture and remediation.

4.1 POC Wells

Three Point of Compliance (POC) wells are designated for the alluvial aquifer at the Grants site; these alluvial wells are D1, X and S4. These wells are, and will continue to be, used to monitor the concentrations of the alluvial aquifer near the toe of the facilities at the Grants site.

Two wells are proposed to become POC wells for the Upper Chinle aquifer since it subcrops with the alluvium underneath the Large Tailings Pile. These two wells are existing Upper Chinle well CE2 and Upper Chinle well CE8, which is just south of the Small Tailings Pile. These two wells are intended to monitor the potential flow paths from the tailings area in the Upper Chinle aquifer. In addition to the POC wells, background wells P and Q will also be monitored. These wells are shown on Figure 49. The proposed monitoring program is outlined in Table 4-1.

The Middle and Lower Chinle aquifers do not subcrop in the area of the Grants site; therefore, groundwater in the alluvial or Upper Chinle must flow beyond the Grants site to have contact with the subcrop areas of Middle and Lower Chinle aquifers. POC wells near the toe of the Large Tailings Pile in the Middle and Lower Chinle aquifers are therefore not appropriate. POC wells are not proposed for the Middle and Lower Chinle aquifers.

4.2 Compliance Monitoring Wells

Wells will be monitored in each of the aquifers to determine the progress of the CAP and identify modifications to the CAP as needed. The additional monitoring wells and monitoring frequency and parameters are outlined in Table 4-1. Figure 49 shows the additional wells proposed for each of the four aquifers.

4.3 QA Program

A comprehensive field and laboratory quality control program has been used, and will continue to be used, to assure the quality of the monitoring data. The program (which is anticipated for use) is presented in Appendix B.

Table 4-1 Proposed Compliance Monitoring Program

Well	Parameters to be Monitored	Frequency of Monitoring
POINT-OF-COMPLIANCE WELLS		
Point-of-compliance wells D1, X, S4, CE2, CE8	B, F H	Annually Semi-Annually
Background wells P, Q	B, F G	Annually Semi-Annually
COMPLIANCE MONITORING WELLS		
ALLUVIAL WELLS		
Broadview Acres wells SUB1, SUB2, SUB3	B, F G	Annually Semi-Annually
Felice Acres wells 490, 491, 496	G	Semi-Annually
Murray Acres wells 802, 844	G	Semi-Annually
Pleasant Valley wells 688, 846	G	Semi-Annually
Regional wells 631, 649, 687, 869, 881, 920, 942	G	Semi-Annually
Site monitoring wells F, FB, GH, GN, MO, MR, MX, R, S2	G	Semi-Annually
Collection system wells	Total volume	Monthly
Injection system wells	Total volume	Monthly
Reversal wells B, BA, KZ, DZ, SO, SP, S2, S5	Water level	Weekly
CHINLE WELLS		
Broadview Acres well CE9	G	Semi-Annually
Felice Acres wells 493, 494, CW45	G	Semi-Annually
Regional wells CW18, CW29, CW42	G	Semi-Annually
Site monitoring wells CW25, CW50	G	Semi-Annually
SAN ANDRES WELLS		
#1 Deep, #2 Deep, 943, 951	D G	Annually Semi-Annually

*Parameters:

B: Water level, pH, TDS, SO_4, Cl, HCO_3, CO_3, Na, Ca, Mg, K, NO_3, U, Se, Mo, Ra-226

D: pH, TDS, Ca, Mg, K, Na, SO_4, Cl, HCO_3, CO_3, NO_3 as N, Se, Mo, Al, As, Ba, Cd, Cu, CN, F, Fe, Pb, Mn, Hg, Ni, Ag, Zn, U, Ra-226 (filtered)

F: V, Ra-228, Th-230

G: Water level, TDS, SO_4, U, Se, Mo

H: Water level, TDS, SO_4, U, Se, Mo, Cl

5.0 FINANCIAL SURETY

A comprehensive financial surety evaluation was submitted (as required by License Condition 28) on March 29, 2006. The cost estimate included a detailed estimate of the cost for implementing the CAP as described in Section 3. The duration and future elements of the CAP are described in Section 3. The total present value cost estimate for the CAP as estimated in the March 29, 2006 financial surety submittal is $55,481,560., which includes a 15 percent contingency and a Long-Term Maintenance/Surveillance fee (required by US NRC).

As required by License Condition 28, the surety estimate will be updated annually and will reflect any deviations from the currently expected CAP.

6.0 CONCLUSIONS

Homstake is proceeding with a comprehensive groundwater corrective action program that is showing effective progress since 1977. This report documents the evolution of the program and presents a Revised CAP to complete the groundwater restoration required at the Grants site.

The program currently consists of over 240 injection wells, 220 extraction wells, an RO treatment plant and land application (irrigation) system. The program has been effective in capturing groundwater and remediating groundwater in the underlying alluvial aquifer as well as the three underlying bedrock aquifers that are hydraulically connected to the alluvial aquifer. The CAP will continue to change as site conditions change and water quality improves in the aquifers. Modifications will be made to optimize the removal of constituents and to bring water quality in each of the aquifers to the approved water quality standards.

7.0 REFERENCES

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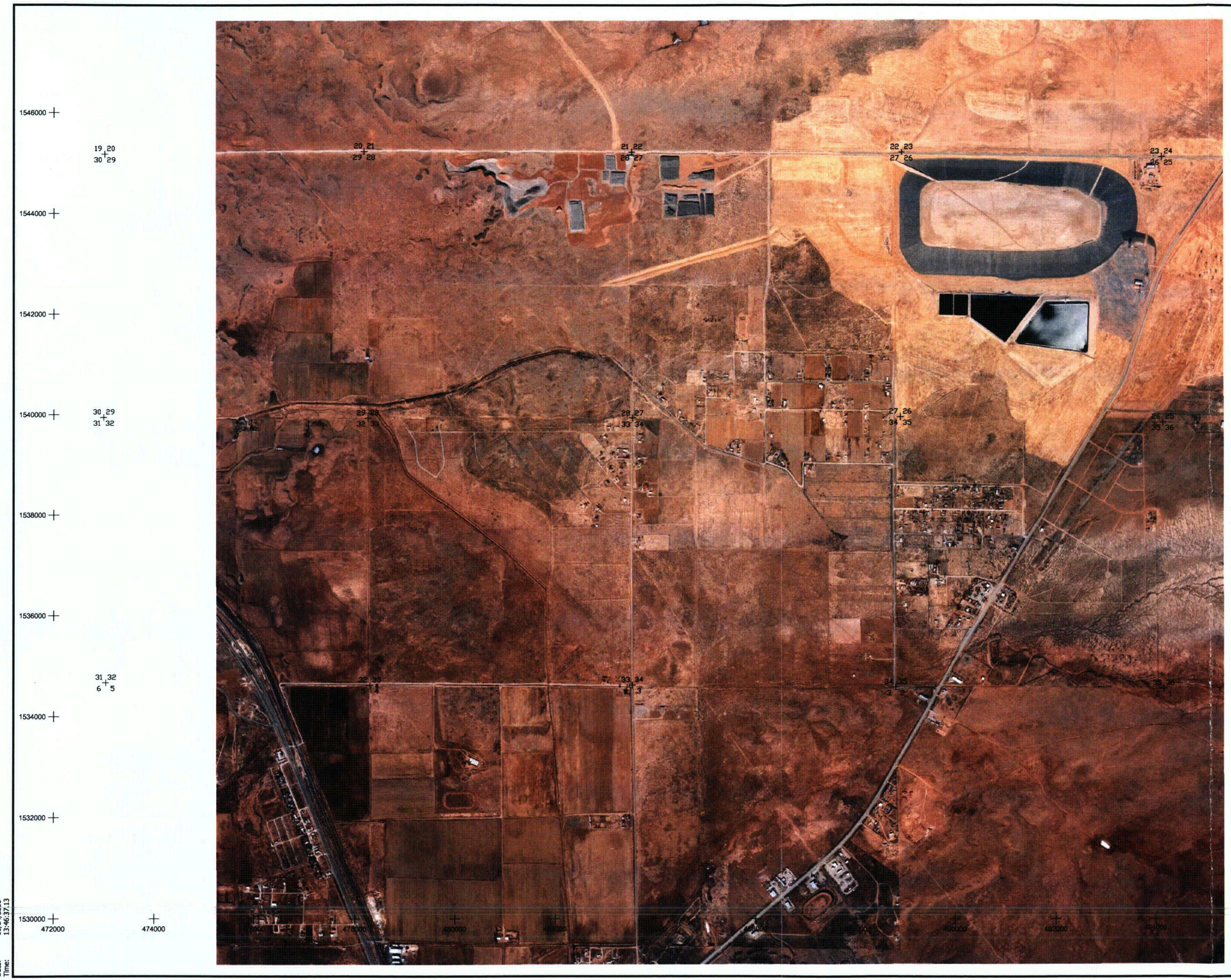

LEGEND:

+ 1536000	NAD 27, NEW MEXICO STATE PLANES, WEST ZONE COORDINATES
35 36 / 2 + 1	SECTION CORNER

NORTH

SCALE IN FEET

0 2000

FIGURE 1
GRANTS MILL SITE AND ADJACENT PROPERTIES AERIAL PHOTO

MFG, Inc.
consulting scientists and engineers

Date:	NOVEMBER 2006
Project:	180899
File:	AERIAL.dwg

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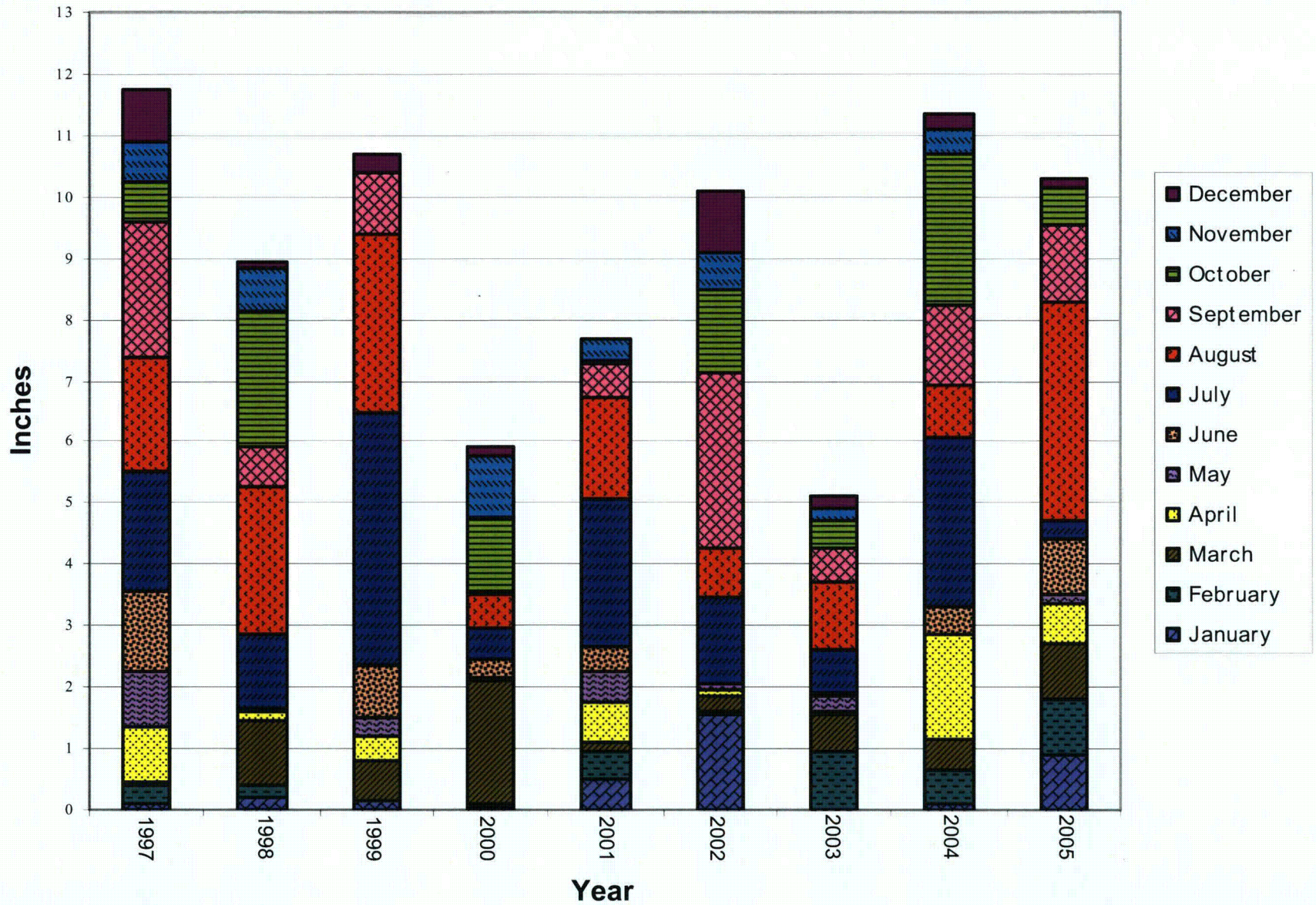
Date: 10/24/2006
Time: 13:46:37.13



MFG, Inc.
consulting scientists and engineers

FIGURE 2
ANNUAL PRECIPITATION, COMPARISON BY MONTH

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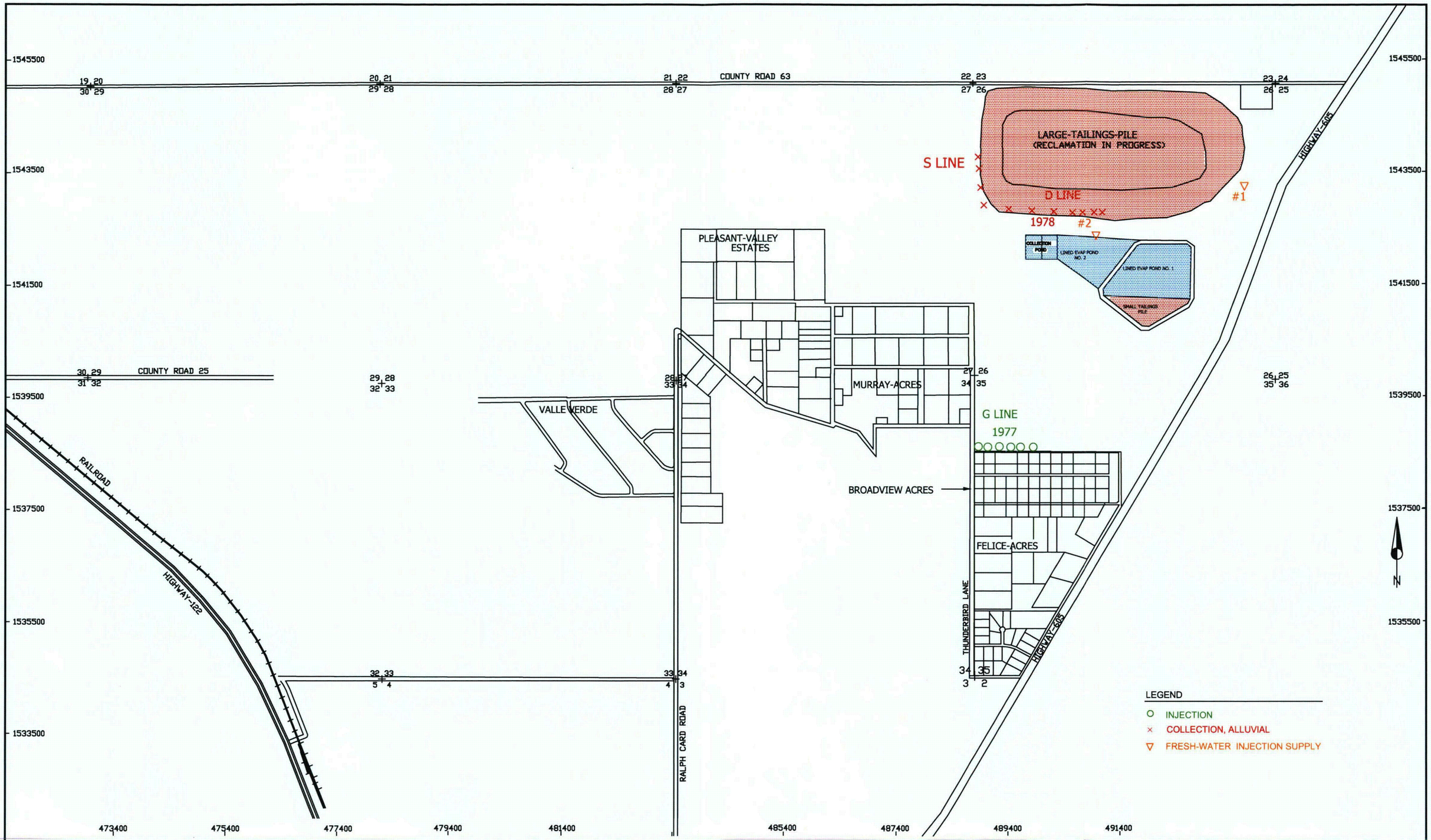
Project:	P:\180899\
File:	FIGURE 2.ppt



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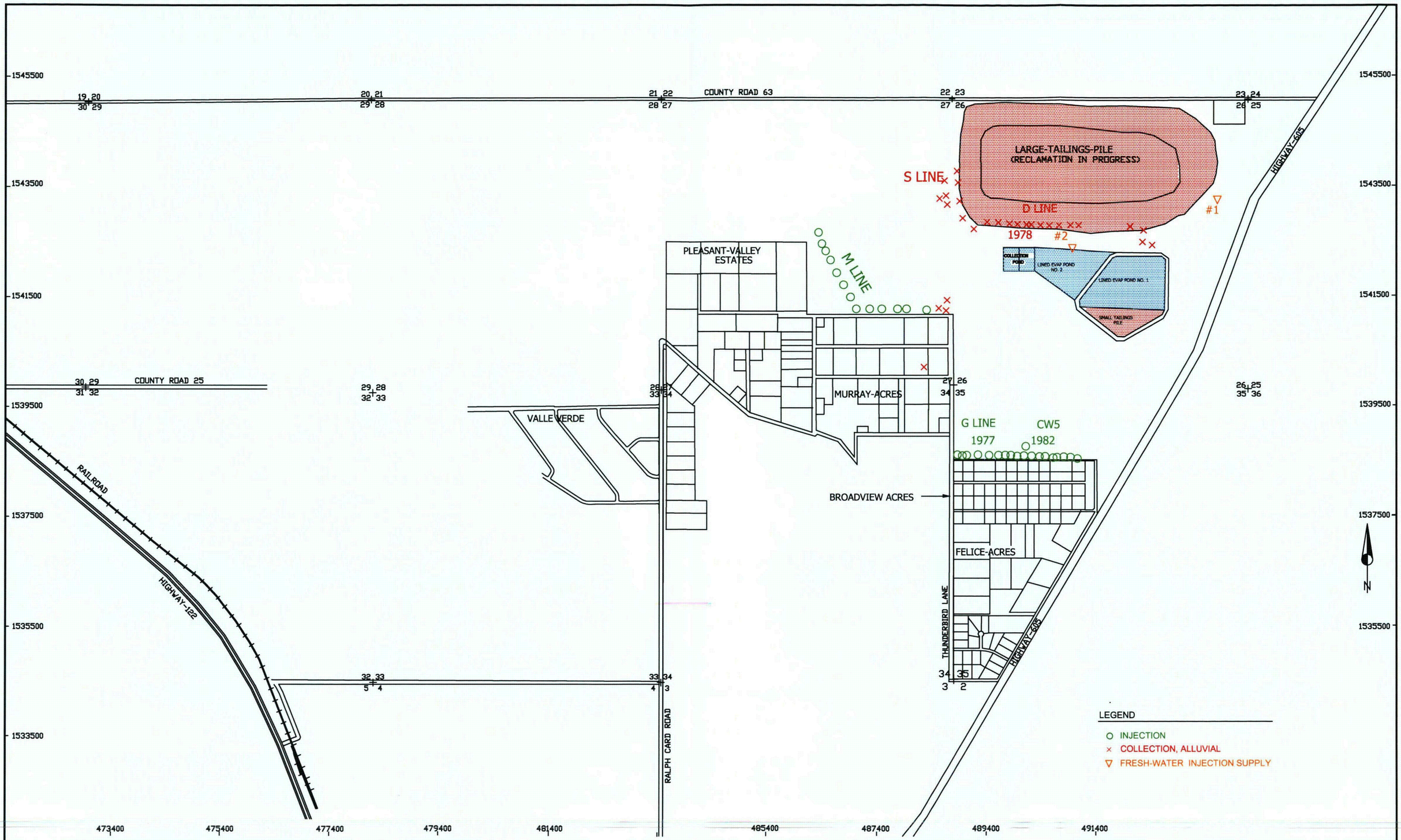
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 3
LOCATION OF COLLECTION/
INJECTION WELLS, 1978



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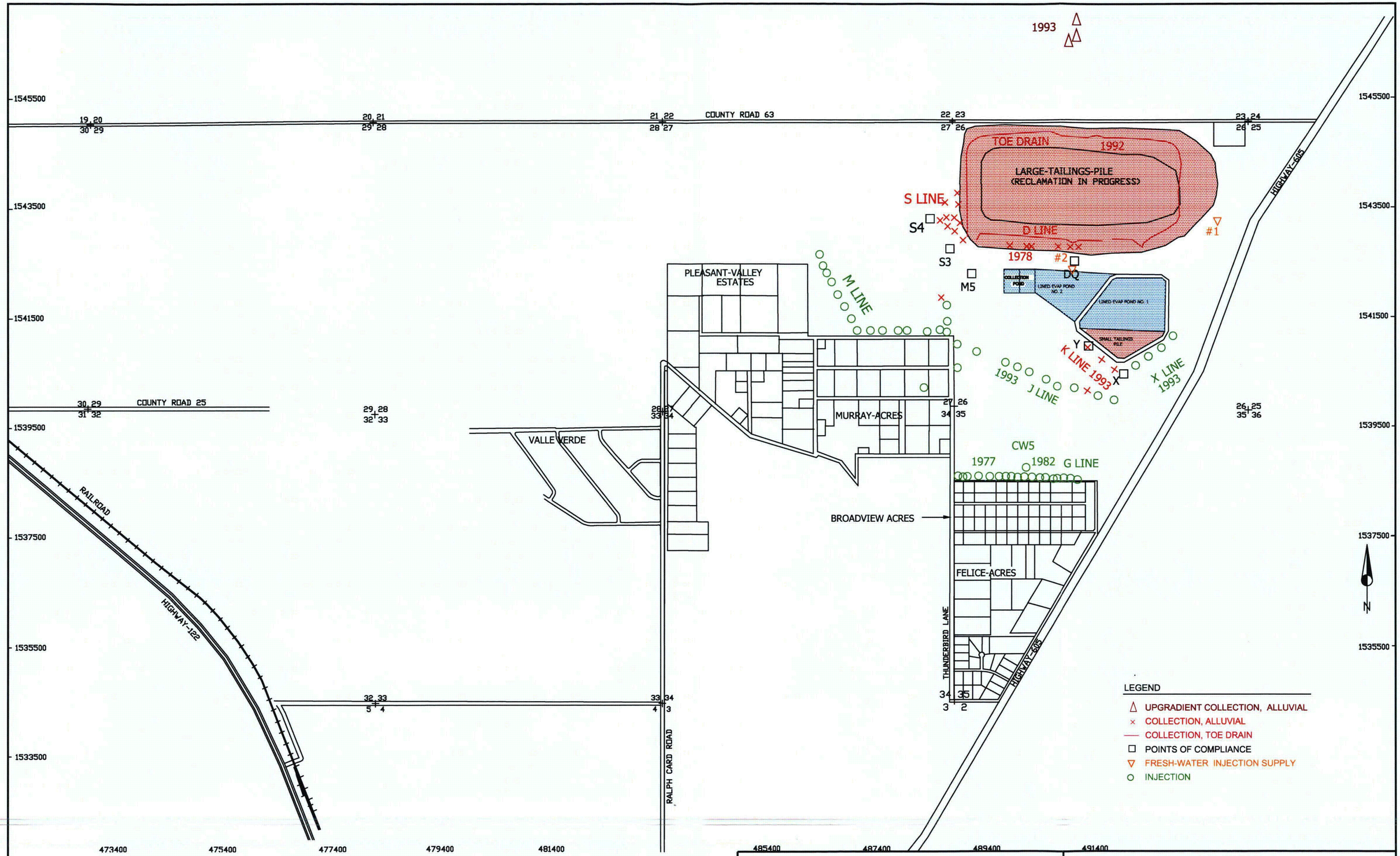
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 4
LOCATION OF
COLLECTION/INJECTION WELLS, 1983

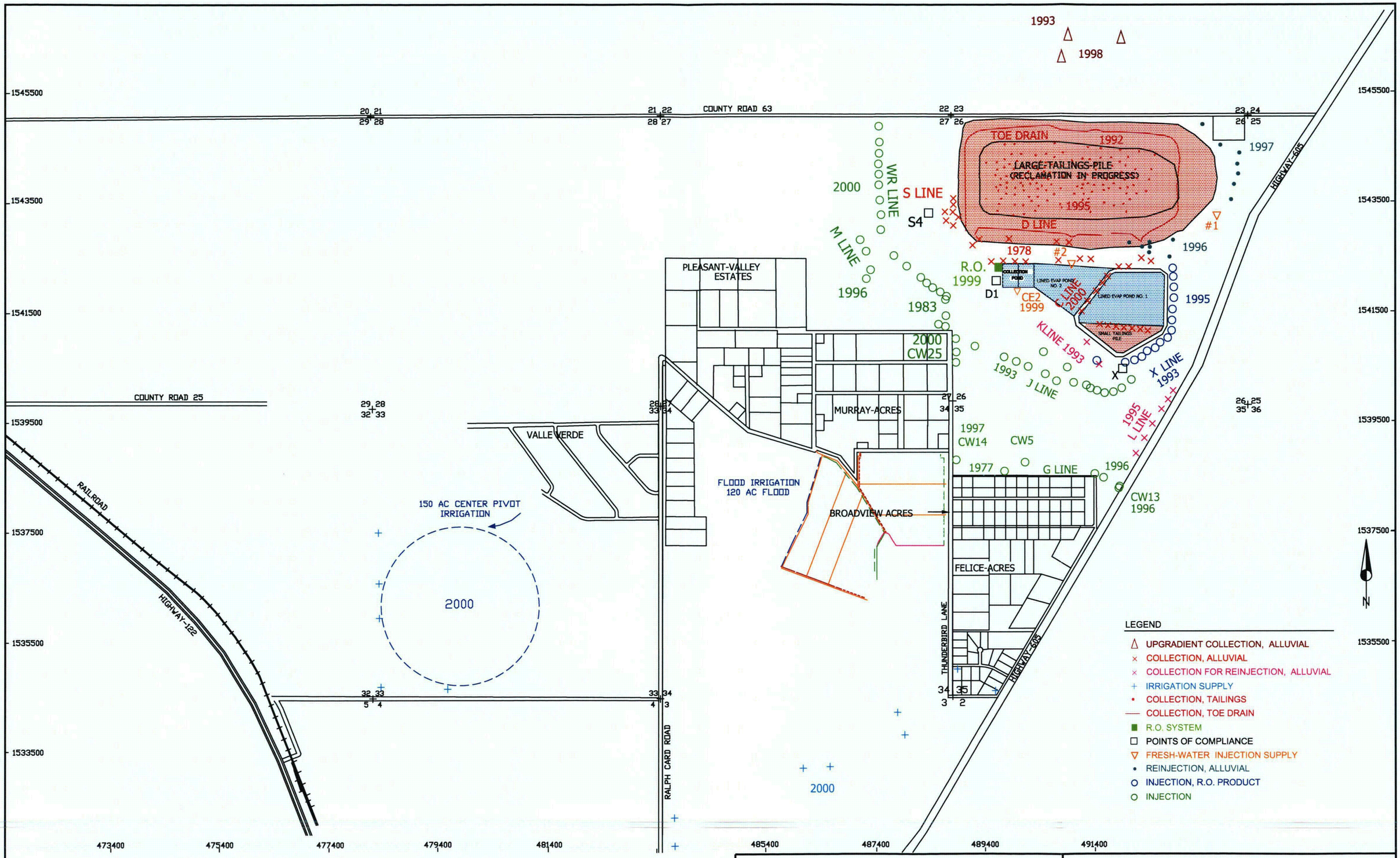


HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 5
LOCATION OF
COLLECTION/INJECTION WELLS, 1993

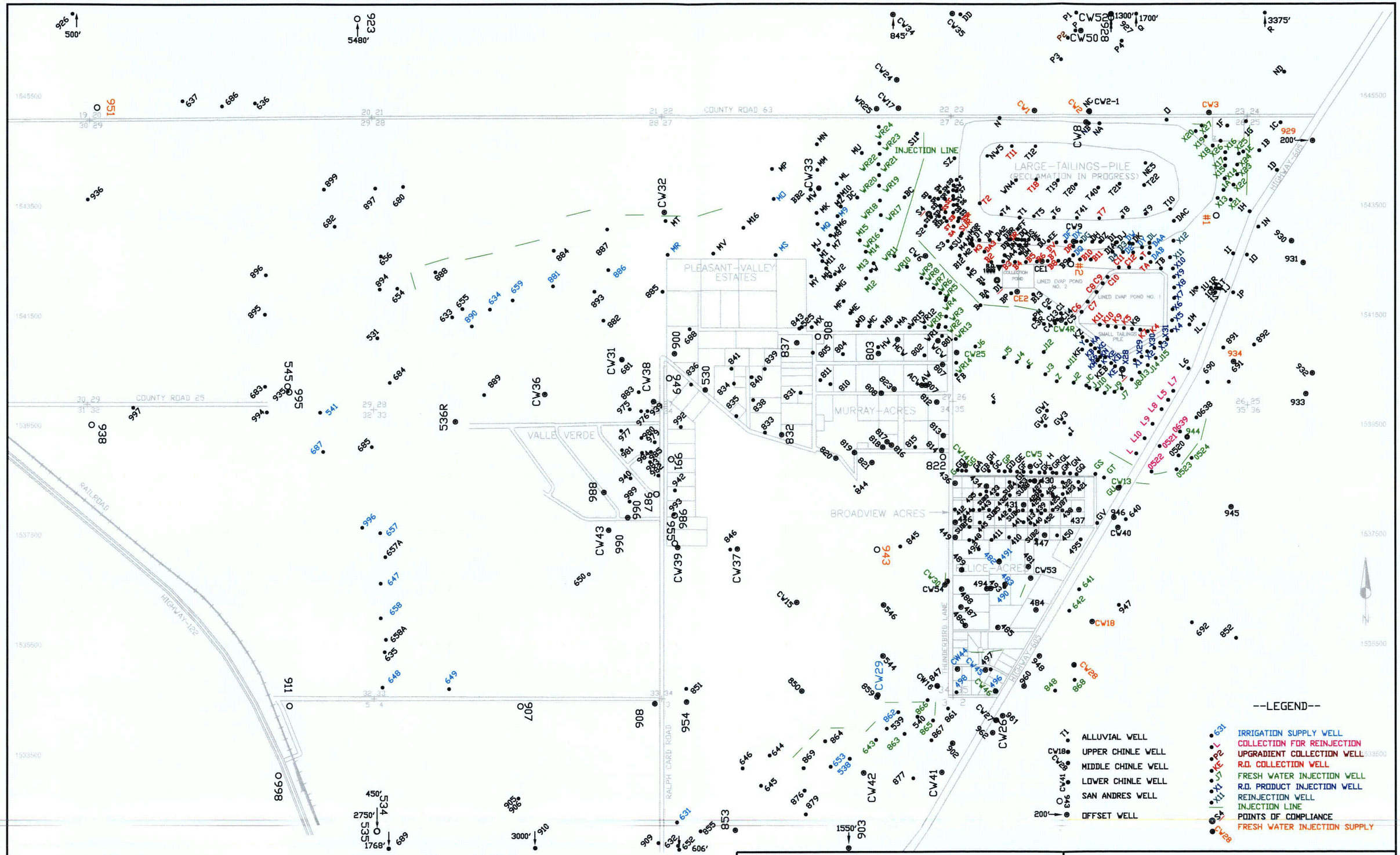
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 6
LOCATION OF COLLECTION/INJECTION WELLS, 1998



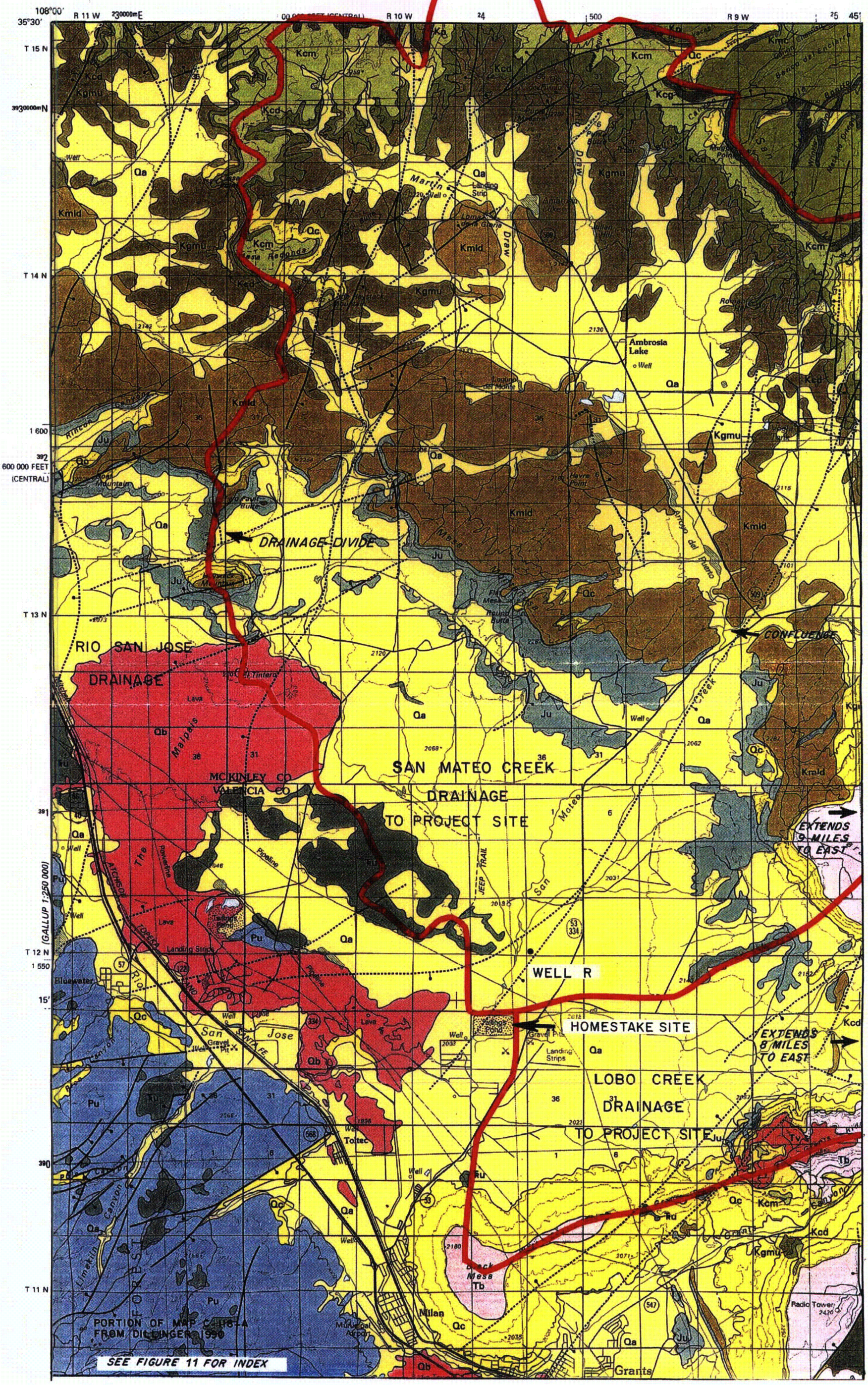
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 7
LOCATION OF COLLECTION/INJECTION AND IRRIGATION WELLS, 2000



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 8
LOCATION OF COLLECTION/INJECTION AND IRRIGATION WELLS, 2005



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

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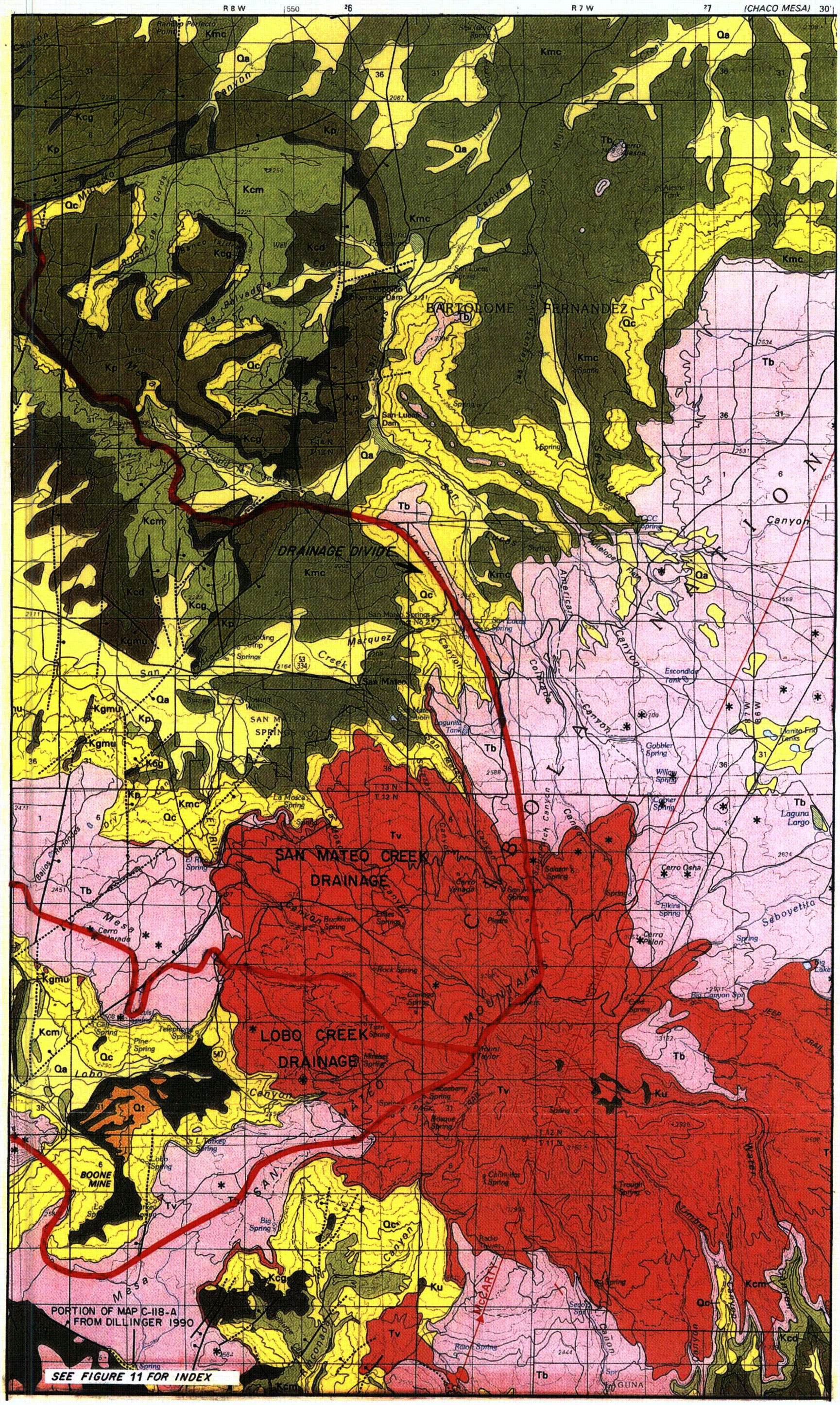
FIGURE 9
SAN MATEO AND LOBO CREEK
DRAINAGE AND SURFACE GEOLOGY

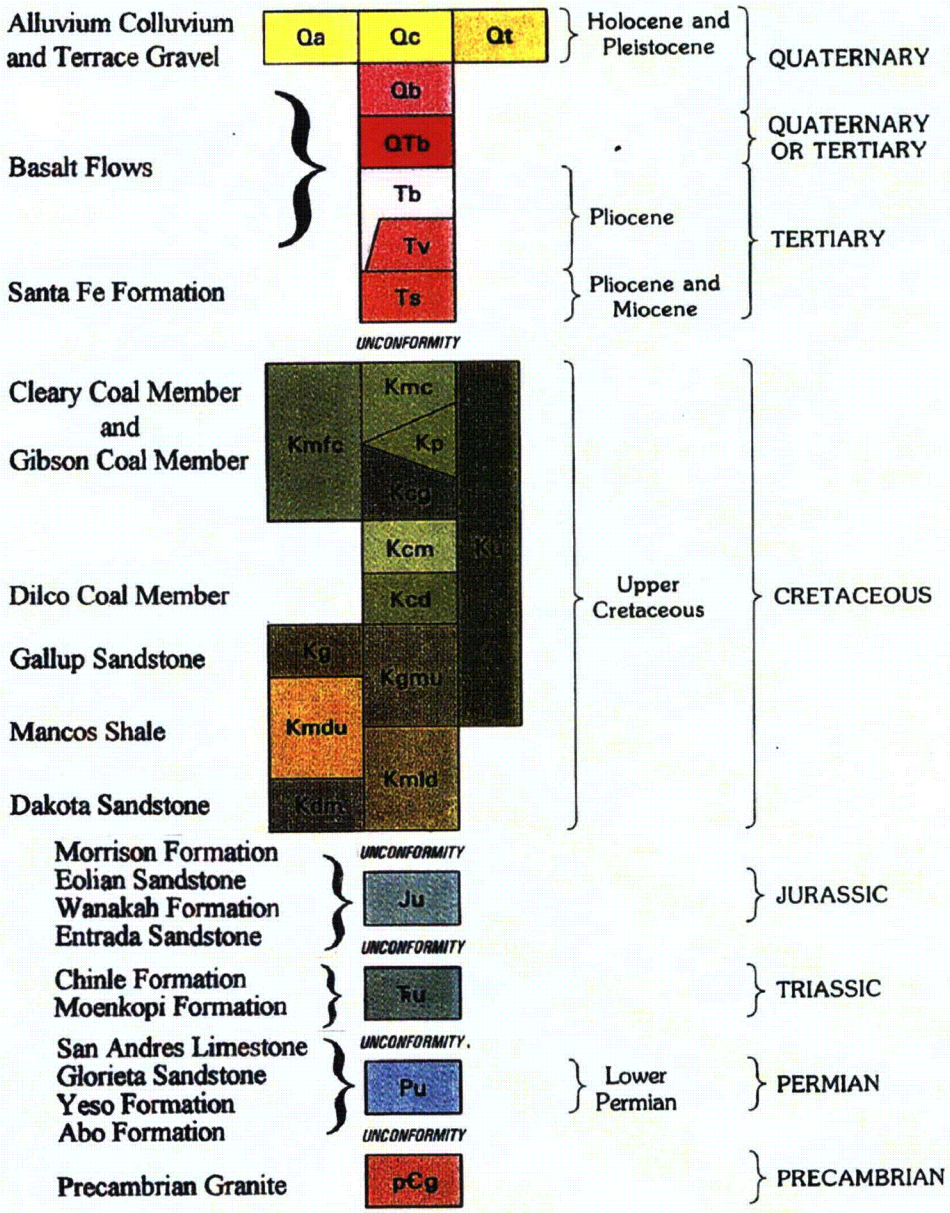


HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

Date: 10/24/2006 Filename: E:\180899\GEO-figs.dwg

FIGURE 10
EASTERN PORTION OF SAN MATEO AND LOBO CREEK DRAINAGE AND SURFACE GEOLOGY

CORRELATION OF MAP UNITS



From Map C-113-A Dillinger, 1990

HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

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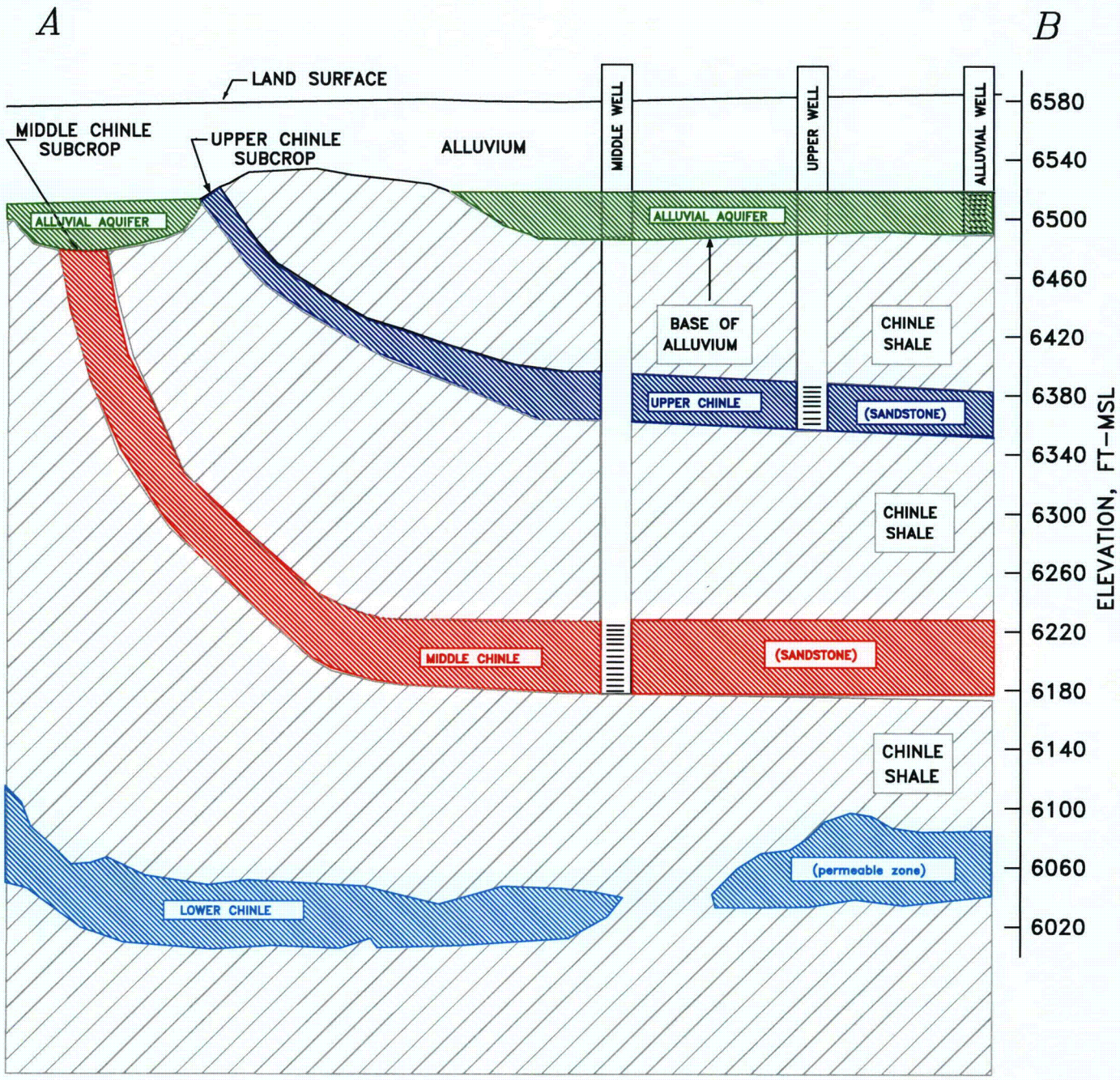
FIGURE 11
GEOLOGIC INDEX FOR FIGURES 9 AND 10



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

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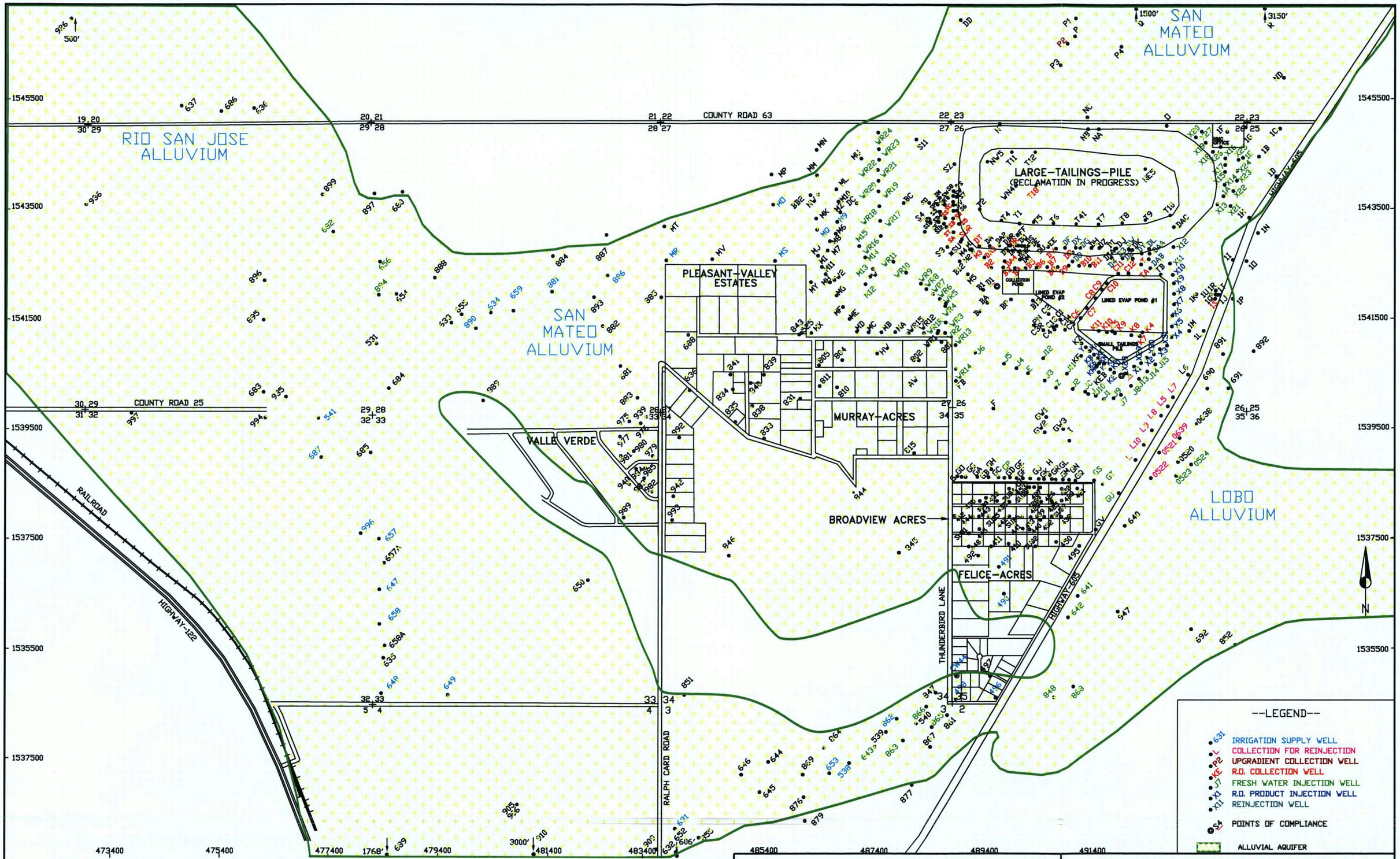
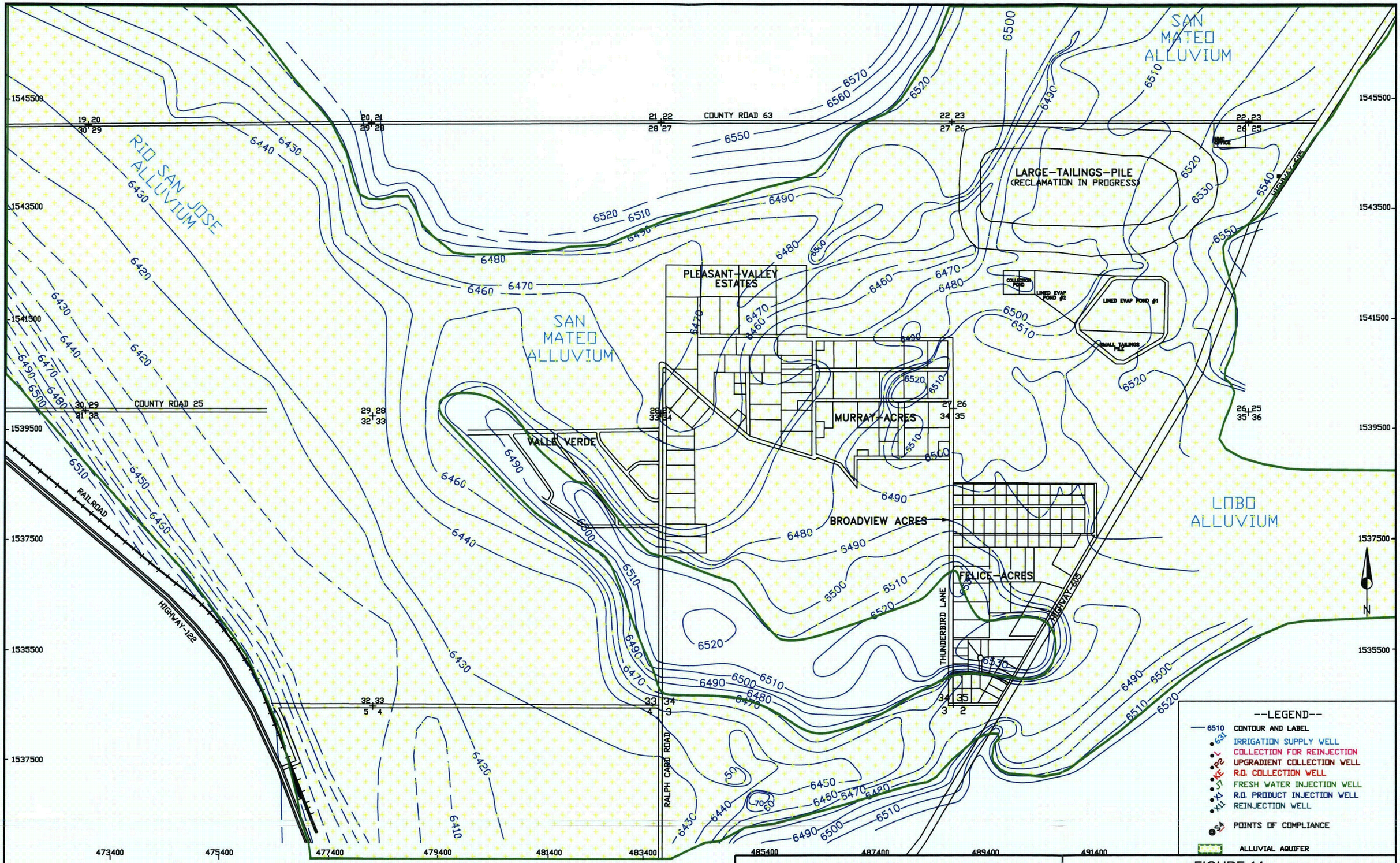
FIGURE 12
TYPICAL GEOLOGIC CROSS SECTION



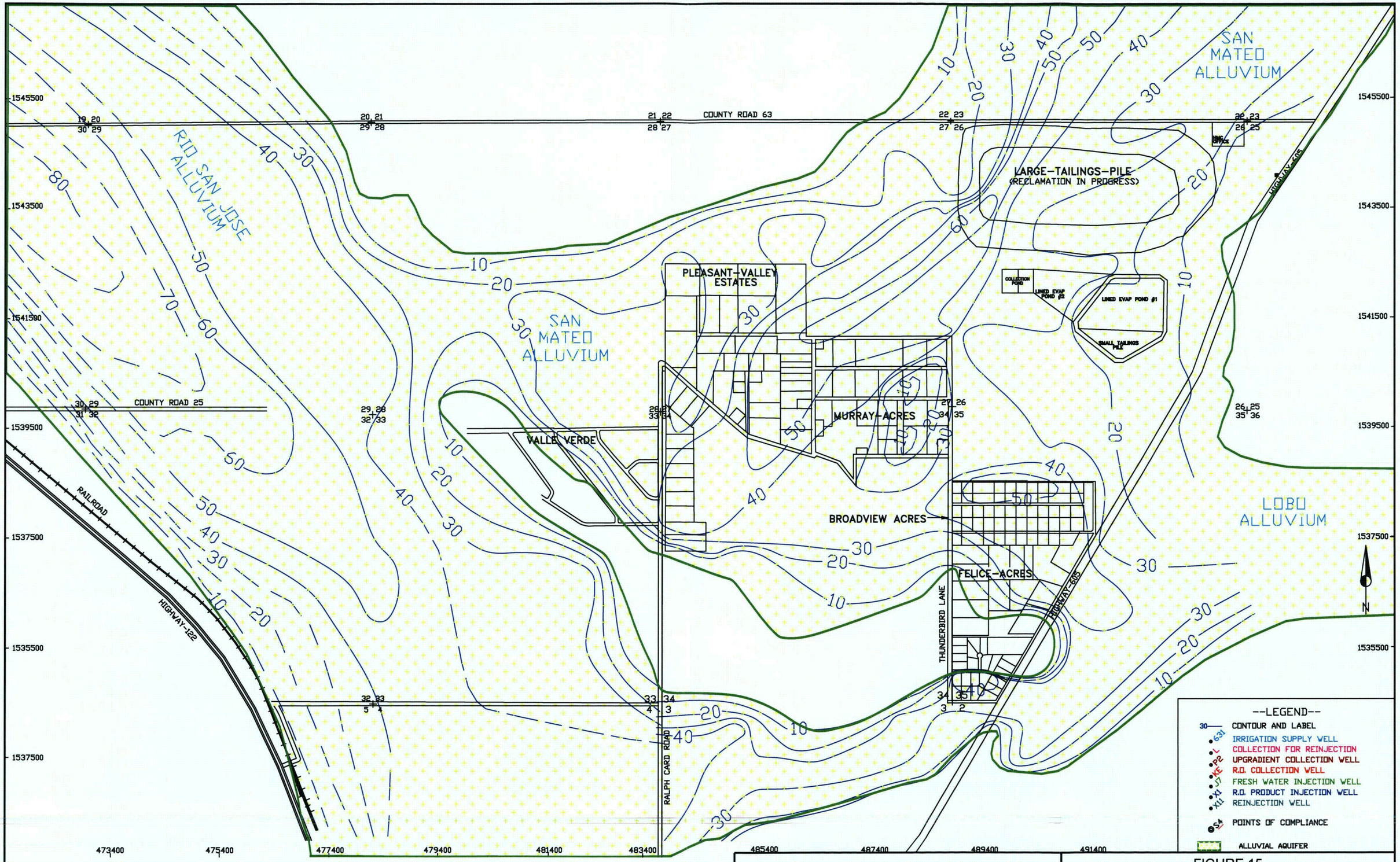
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 13
ALLUVIAL WELL LOCATIONS



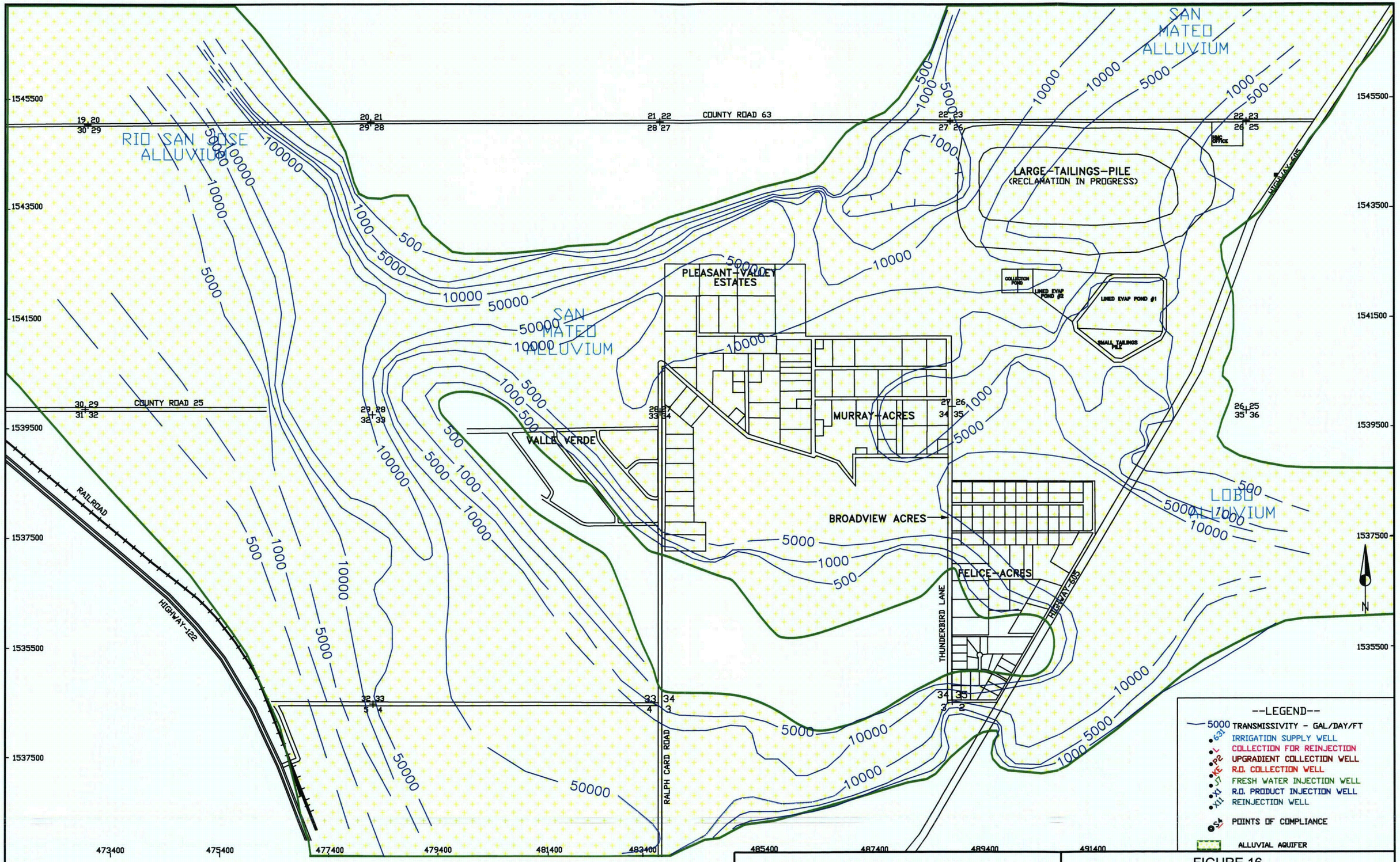
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 14
ELEVATION OF THE BASE OF THE ALLUVIUM, IN FT-MSL



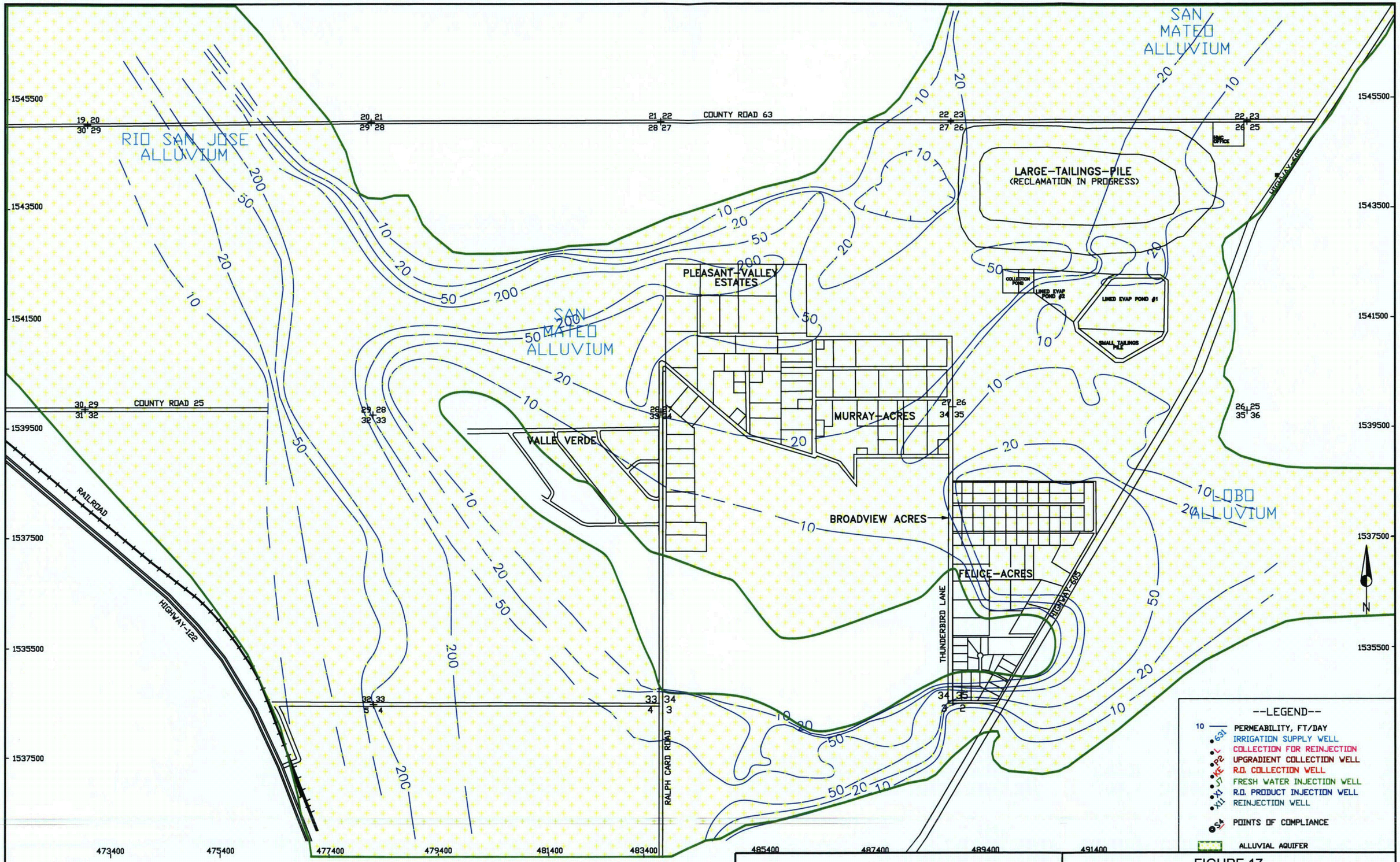
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 15
SATURATED THICKNESS OF THE ALLUVIAL AQUIFER, 2002, FEET



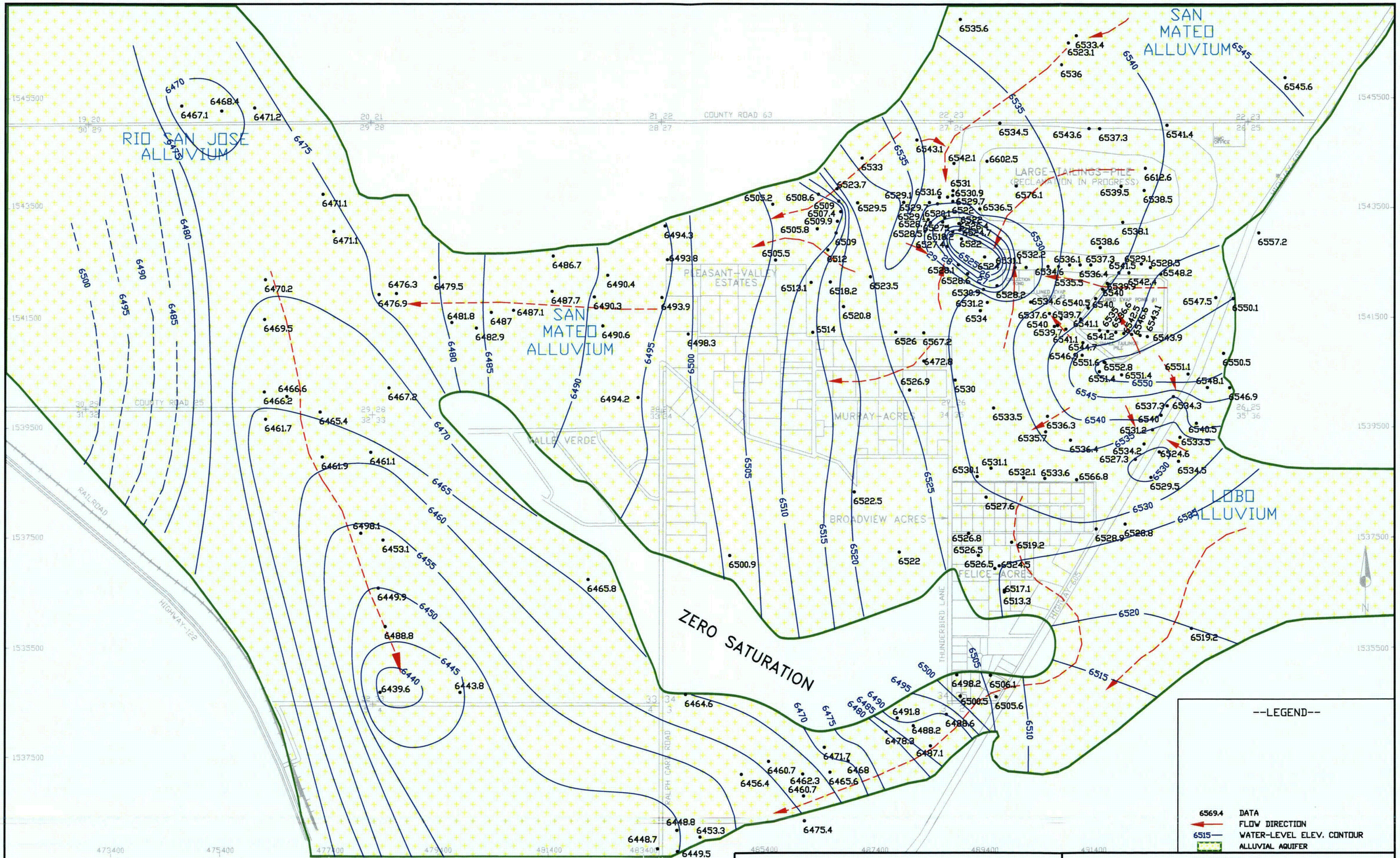
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 16
TRANSMISSIVITY FOR THE ALLUVIAL AQUIFER, GPD/FT



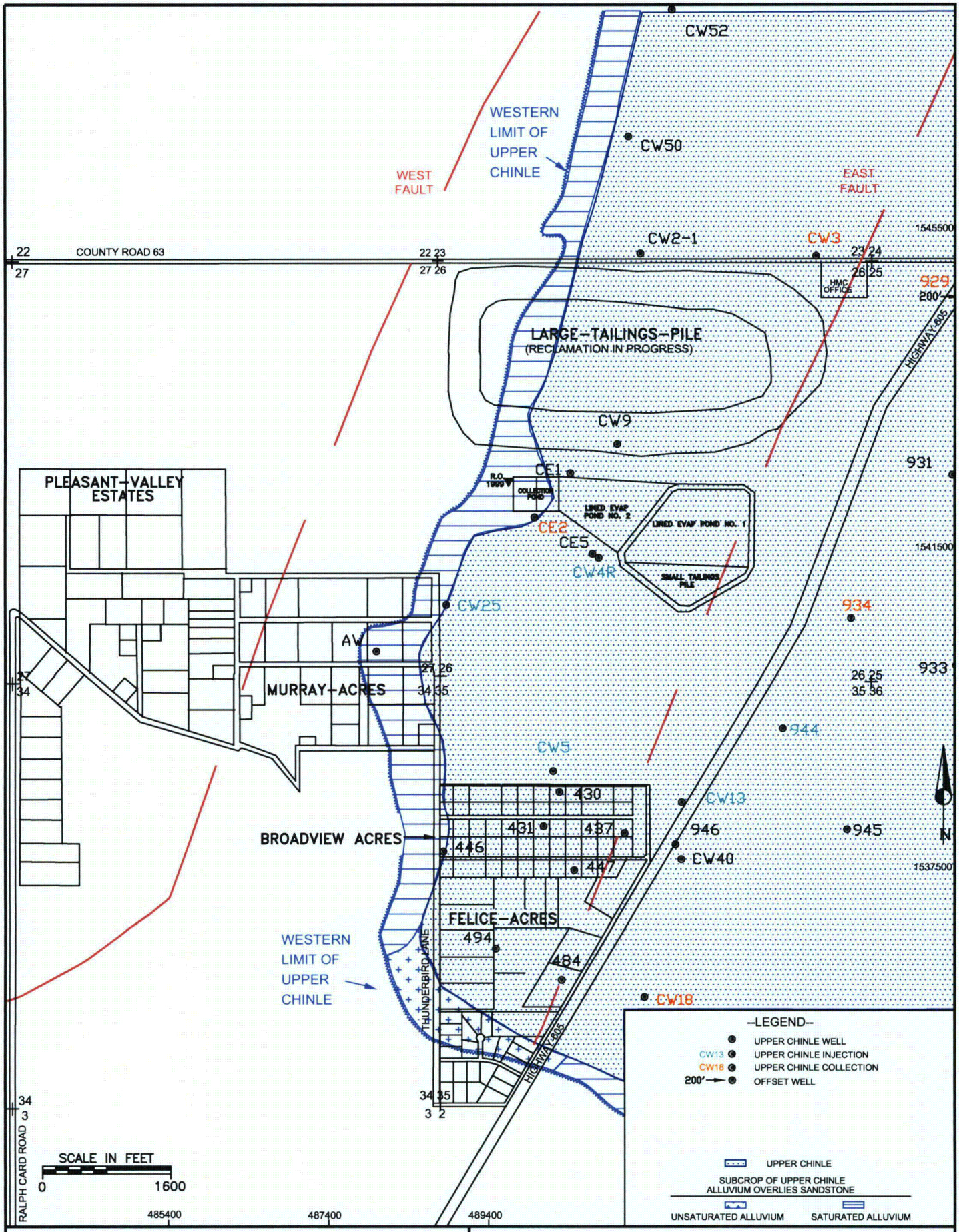
HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 17
HYDRAULIC CONDUCTIVITY (PERMEABILITY) OF THE ALLLUVIAL AQUIFER, FT/DAY



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

FIGURE 18
WATER-LEVEL ELEVATION FOR THE ALLUVIAL AQUIFER, FALL 2005, FT-MSL



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

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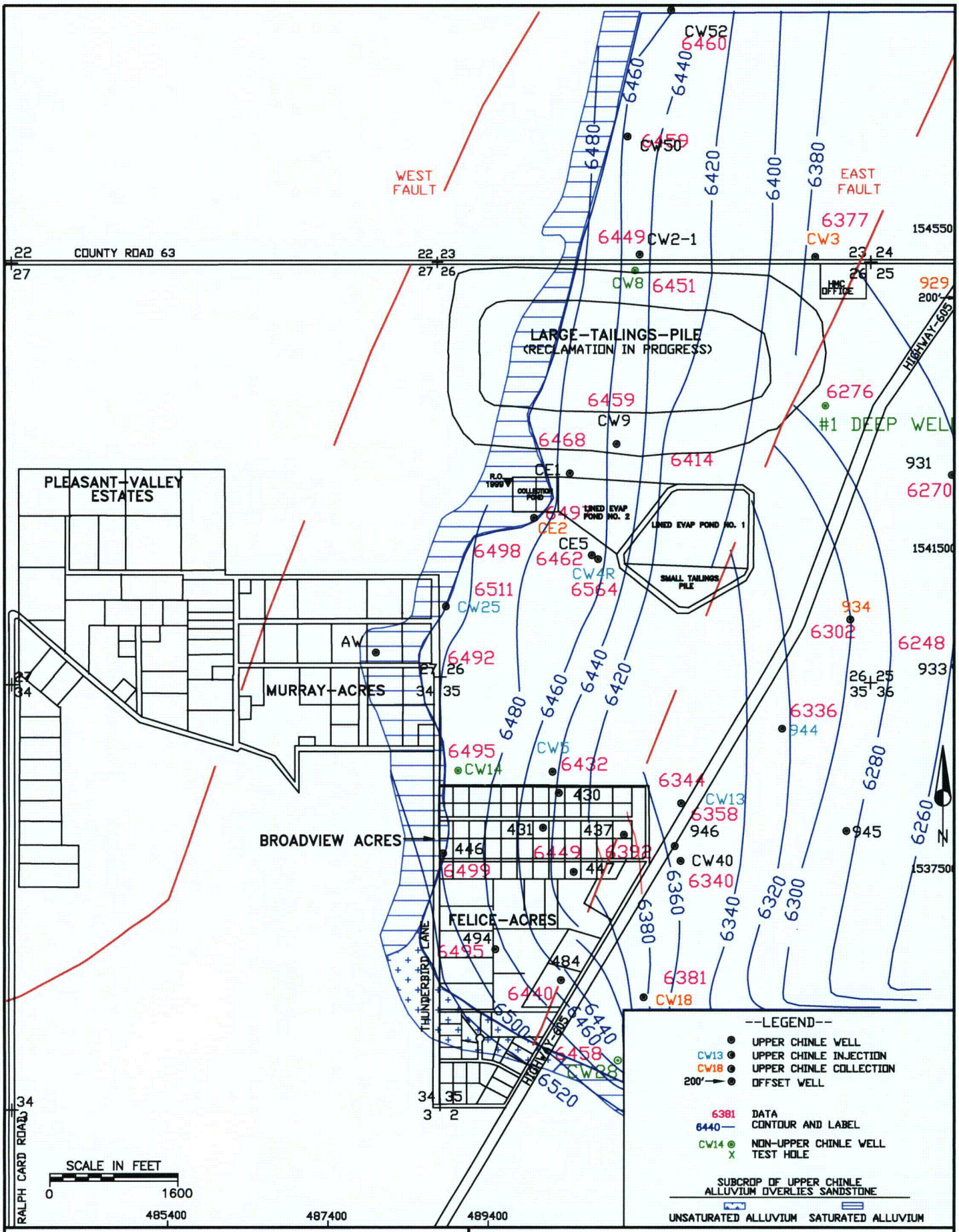
FIGURE 19
LIMITS OF UPPER CHINLE AQUIFER AND WELL LOCATIONS



HOMESTAKE-MILL-AND-ADJACENT-PROPERTIES
GRANTS-NM-TOWNSHIP-11&12-N-RANGE-10-W

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FIGURE 20
ELEVATION OF THE TOP OF THE
UPPER CHINLE AQUIFER, FT-MSL